Vol. XXI.—No. 119] [December, 1927.

THE

MINERALOGICAL MAGAZINE

AND

Journal of

The Mineralogical Society

(*INSTITUTED FEBRUARY 8, 1876.*)

WITH A SEPARATELY-PAGED APPENDIX OF

MINERALOGICAL ABSTRACTS

EDITED BY L. J. SPENCER, F.R.S.

ABSTRACTORS

F. N. ASHCROFT.
T. V. BARKER.
H. E. BUCKLEY.
P. N. CHIRVINSKY.
T. CROOK.
A. F. HALLIMOND.
HAROLD HILTON.
E. D. MOUNTAIN.
R. ŌHASHI.
A. L. PARSONS.
G. T. PRIOR.
W. A. RICHARDSON.
S. J. SHAND.
F. SLAVÍK.
W. CAMPBELL SMITH.
L. J. SPENCER.
K. ZIMÁNYI.

LONDON:
HUMPHREY MILFORD, OXFORD UNIVERSITY PRESS,
AMEN HOUSE, WARWICK SQUARE, E.C. 4.

1927.

Price 6s. net.
Annual Subscription for four numbers, Post free 20s.

MINERALOGICAL SOCIETY

Officers and Council for 1927–28.

PRESIDENT.

G. T. Prior, M.A., D.Sc., F.R.S.

PAST-PRESIDENTS.

Sir Henry A. Miers, M.A., D.Sc., LL.D., F.R.S. (1904–1909).
A. E. H. Tutton, M.A., D.Sc., F.R.S. (1912–1915).
W. Barlow, F.R.S. (1915–1918).
Prof. A. Hutchinson, O.B.E., M.A., Ph.D., F.R.S. (1921–24).
Prof. W. W. Watts, M.A., M.Sc., Sc.D., LL.D., F.R.S. (1924–27).

VICE-PRESIDENTS.

Sir T. H. Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S.
Sir J. S. Flett, K.B.E., M.A., LL.D., D.Sc., F.R.S.

TREASURER.

F. N. Ashcroft, M.A., F.G.S., F.C.S., 1 *Egerton Gardens, South Kensington, London, S.W.* 3.

GENERAL SECRETARY.

W. Campbell Smith, M.C., M.A., F.G.S., *Natural History Museum, South Kensington, London, S.W.* 7.

FOREIGN SECRETARY.

J. W. Evans, C.B.E., LL.B., D.Sc., F.R.S., *Imperial College of Science and Technology, South Kensington, London, S.W.* 7.

EDITOR OF THE JOURNAL.

L. J. Spencer, M.A., Sc.D., F.R.S., *Natural History Museum, South Kensington, London, S.W.* 7.

TRUSTEES.

F. N. Ashcroft, M.A., F.G.S., F.C.S.
Sir Henry A. Miers, M.A., D.Sc., LL.D., F.R.S.

ORDINARY MEMBERS OF COUNCIL.

Prof. P. G. H. Boswell, O.B.E., D.Sc., F.G.S.
Prof. H. L. Bowman, M.A., D.Sc., F.G.S.
A. J. Bull, M.Sc., F.Inst.P., F.G.S.
T. Crook, A.R.C.Sc.I., F.G.S.
Prof. C. G. Cullis, D.Sc., F.G.S.
Prof. W. T. Gordon, M.A., D.Sc., F.R.S.E.
L. Hawkes, D.Sc., F.G.S.
H. F. Harwood, M.Sc., Ph.D., A.I.C.
Prof. Harold Hilton, M.A., D.Sc.
W. F. P. McLintock, D.Sc., F.G.S.
G. F. Herbert Smith, M.A., D.Sc., F.G.S.
H. H. Thomas, M.A., Sc.D., F.R.S.

LIBRARIAN.

Prof. A. Hutchinson, M.A., Ph.D., F.R.S., *The New Museums, Cambridge* (to which address all publications intended for the Library of the Society should be forwarded).

Bankers.—Messrs. Coutts & Co., 15 *Lombard Street, London, E.C.*

THE MINERALOGICAL MAGAZINE

AND

JOURNAL OF

THE MINERALOGICAL SOCIETY.

No. 119. December, 1927. Vol. XXI.

Specific gravities of minerals: an index of some recent determinations.

By L. J. Spencer, M.A., Sc.D., F.R.S.
Keeper of Minerals in the British Museum
(Natural History).

[Read November 1, 1927.]

As a first-aid in the identification of non-metallic minerals I have for many years[1] made use of specific gravity, which is a character that can be easily and rapidly determined by the use of heavy liquids. A small, clean fragment of the mineral to be tested is dropped into one or other of a series of tubes containing methylene iodide with various small known crystals as indicators. Adding benzene from a dropping-bottle, the density of the liquid is quickly brought to that of the mineral. This preliminary determination of the specific gravity gives a useful clue as to the nature of the mineral—what it may or may not be; and the same fragment can then be used for confirmatory optical and micro-chemical tests.

The set that I have used consists of eight small glass tubes carried in holes bored in a wooden block measuring $11 \times 7 \times 6$ cm. The methylene iodide is thus protected from the light; and any darkening of the liquid is easily corrected by occasionally leaving a piece of copper wire in the tube. Methylene iodide is expensive, but 1 c.c. or even less is sufficient

[1] L. J. Spencer, Min. Mag., 1897, vol. 11, p. 186.

in each tube. A smaller portable set on the same lines would be useful to prospectors. A similar set of tubes for molten thallium-silver nitrate (sp. gr. 5·0) diluted with water has also been used,[1] but this was found to be much less practical. Clerici's solution,[2] consisting of an aqueous solution of thallium formate and malonate (sp. gr. 4·0 at 10° and about 5·0 near 100° C.), is said to be convenient for use and has a wider range than methylene iodide (sp. gr. 3·33), but this I have not had the opportunity of trying. For use as indicators in these liquids a large series of clear crystal fragments has been carefully selected, ranging from sylvine (sp. gr. 1·99) to baryte (sp. gr. 4·48). Of these the following have been found to be the most convenient for use in the eight tubes of methylene iodide.

		Sp. gr.			Sp. gr.
No. 1.	Chabazite ...	2·12	No. 5.	Quartz (Rock-crystal)	2·65
	Heulandite ...	2·20		Beryl (Aquamarine)	2·69
	Scolecite	2·30		Calcite (Iceland-spar)	2·72
No. 2.	Gypsum	2·32	No. 6.	Anorthite	2·75
	Apophyllite ...	2·35		Dolomite	2·85
	Colemanite ...	2·42		Aragonite	2·94
No. 3.	Petalite	2·45	No. 7.	Phenakite	2·98
	Leucite	2·47		Tourmaline (pink) ...	3·02
				Fluorite	3·18
No. 4.	Orthoclase ...	2·56	No. 8.	Apatite	3·20
	Nepheline ...	2·60		Axinite	3·29
	Albite	2·64		Dioptase	3·32

The position of an unknown fragment between two indicators can be approximately judged from the amount of benzene added to the mixture, or from the times taken for each fragment to rise as the benzene evaporates (this can be accelerated with a blowpipe).

In this connexion I have made constant use of the concise table of specific gravities given as an appendix in Sir Henry A. Miers's 'Mineralogy' (1902, pp. 556–561). That table was compiled mainly from Dana's 'System of Mineralogy' (sixth edition, 1892) and gives an estimated mean value to two places of decimals for each mineral species. The more elaborate table of specific gravities published by M. Websby[3] in 1868 is not so clearly set out, and is less convenient for reference. In addition to estimated mean values taken from the text-books he also gave a number of actual values taken from the current literature.

[1] L. J. Spencer, Min. Mag., 1904, vol. 14, p. 48.

[2] Min. Abstr., vol. 2, p. 487.

[3] M. Websky, Die Mineral-Species nach den für das specifische Gewicht derselben angenommenen und gefundenen Werthen. Breslau, 1868, vi + 170 pp.

In the following table only actually determined values of specific gravity are listed. These are from the mineralogical literature for the years 1910–27 and have been collected in the first place from 'Mineralogical Abstracts' (in which the literature for 1915–27 is noticed), supplemented in large part from the International Tables of Constants (covering the literature for 1910–24). A brief reference is given to these in each case, so that it is possible to trace the original source of each determination. The addition of author and date would have been a useful guide, but this would have added considerably to the length of the index. The following abbreviations have been used, and the volumes noted indexed :—

M.A. = Mineralogical Abstracts (issued with the Mineralogical Magazine), vol, **1**, 1920–22 ; vol. **2**, 1923–25 ; vol. **3**, 1926–27 (to no. 7, p. 364).

M.M. = Mineralogical Magazine, vol. **15** (no. 72), 1910, to vol. **21** (no. 118), 1927.

T.A. = Tables annuelles de constantes et données numériques de chimie, de physique et de technologie. Paris, Cambridge, and Chicago.

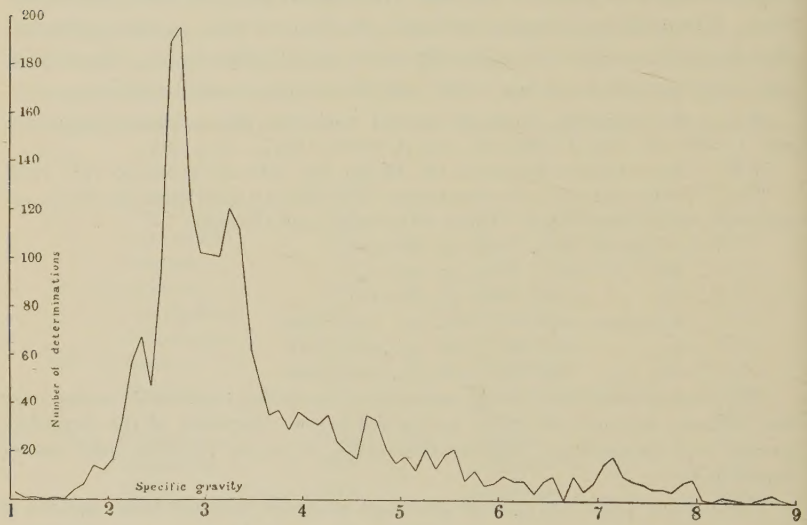
Vol. **1** (année 1910), 1912, pp. 538–559.
,, **2** (,, 1911), 1913, pp. 616–621.
,, **3** (,, 1912), 1914, pp. 426–433.
,, **4** (années 1913–16), 1922, pp. 1026–1056.
,, **5** (,, 1917–22), 1926, pp. 1286–1342.
,, **6** (,, 1923–24), 1928, pp. 1226–1252.

[The arrangement there being alphabetical according to mineral names, only the volumes, and not the pages, are quoted below. Reprints of the Crystallography and Mineralogy chapters from vols. 3, 4, and 5 have been issued separately.]

The number (2277) of specific gravities collected through these sources is by no means complete for the period mentioned. It represents rather the selection that was made at the time of recording for the Abstracts and for the Tables of Constants. Isolated and doubtful determinations, usually made solely for the purposes of identification, were generally omitted, and preference was given to cases where other constants had been also determined on the same sample of material. Many of these are, however, still open to criticism ; and this is especially evident from the minimum and maximum recorded values given in the second table below in the alphabetical list of mineral names. The values are copied as in the original papers, but in a few cases they have been cut down to three places of decimals. Unfortunately it is not always clear from the original papers whether the specific gravity as given is the value compared with water at the temperature of the experiment or the corrected density (weight in grams of 1 c.c. in vacuo).[1]

[1] See A. Hutchinson, A graphical method for the rapid correction of specific gravity determinations. Min. Mag., 1924, vol. 20, pp. 198–200, pl. IV ; L. Ahlers, Zeits. Krist., 1924, vol. 59, p. 293 [Min. Abstr., vol. 2, p. 374].

The data here given are limited to the direct determinations of specific gravity, and do not include the many values recently determined from crystal-structures as determined by X-ray methods. This method may perhaps come to be of importance in cases where only small amounts of pure material are available for examination. At present, however, some discrepancies are to be noted. For example, the following values have



Frequency-curve of the specific gravity of minerals.[1]

been recently and independently given for the density of mercury telluride HgTe (coloradoite): 8·025 (W. Hartwig, 1926), 8·20 (W. F. de Jong, 1926), and 8·42 (W. Zachariasen, 1926).[2] Still it must be remembered that previous determinations for coloradoite by ordinary methods show far greater variations: 8·627 (F. A. Genth, 1877), 9·21 (E. S. Simpson, 1898), and 8·07 (L. J. Spencer, 1903).[3]

In the numerical index it will be noticed that there is a great preponderance of determinations between 2·0 and 4·0, nearly three-quarters of the values (1646 out of 2277) falling between these limits. Counting the number of determinations for each tenth of a unit, i.e. those falling between 2·0–2·099, 2·1–2·199, &c., the greatest number (195) is at 2·7–

[1] Forty-four values from the last number (no. 118) of the Magazine are not included in this diagram.

[2] Min. Abstr., vol. 3, p. 178.

[3] Min. Mag., 1903, vol. 13, p. 276.

2.799. The accompanying frequency-curve has been obtained by plotting the number of determinations between these limits as 2·05, 2·15, 2·75, &c. The two smaller peaks at the sides of the remarkable peak at 2·75 correspond with the accidental number of determinations for zeolites and the ferromagnesian rock-forming minerals. The curve rises on the left much more steeply than on the right, and the average for all the values is shifted to the right. An approximate arithmetical mean has been arrived at by reckoning 195 values as 2·75, &c. This gives the average value 3·62. The mode at 2·75 corresponds closely with H. S. Washington's (1920)[1] value of 2·77 (or 2·75) for the average density of the earth's crust. The above average value 3·62 no doubt indicates that the number of determinations made on metallic minerals is greater than the relative abundance of such minerals in the earth's crust.

Numerical Index of determined Specific Gravities of Minerals.

1·03	Retinite	M.A. 3-218
1·051	,,	M.A. 3-218
1·092	Flagstaffite	M.A. 1-123
1·122	Schungite	M.A. 2-191
1·21	Curtisite	M.A. 3-239
1·43	Hoelite	M.A. 2-10
1·541	Ajkaite	M.A. 3-362
1·645	Tschermigite	M.A. 1-344
1·664	Tachyhydrite	T.A. 4
1·665	,,	T.A. 1
1·669	,,	M.A. 3-298
1·718	Alunogen	M.A. 3-354
1·72	,,	T.A. 3
1·735	,,	T.A. 3
1·75	Quisqueite	T.A. 1
—	$CaCO_3.6H_2O$ (art.)	M.A. 1-166
1·757	Hexahydrite	T.A. 2
1·777	$CaCO_3.6H_2O$ (art.)	M.A. 2-217
1·807	Halotrichite	T.A. 3
1·81	Chlorophaeite	M.M. 20-437
1·815	Delvauxite	M.A. 2-142
1·830	$CaCO_3.5H_2O$ (art.)	M.A. 3-165
1·833	,,	M.A. 3-165
1·835	,,	M.A. 3-164
1·84	Pickeringite	M.A. 3-354
1·845	Anthraxolite	M.A. 2-191
1·85	Thaumasite	T.A. 2
1·875	Inyoite	M.A. 1-410
1·877	Thaumasite	T.A. 5
1·879	,,	T.A. 5
1·88	Allophane	M.A. 2-470
1·885	Inyoite	M.A. 1-410
1·899	Halotrichite	T.A. 3
1·90	Allophane	M.A. 2-470
1·901	Fibroferrite	M.A. 2-40
1·91	Ulexite	M.A. 1-341
1·924	Evansite	M.A. 2-142
1·929	,,	M.A. 3-349
1·93	Trudellite	M.A. 3-112
1·94	Allophane	T.A. 4
1·94	Racewinite	M.A. 1-23
1·950	Pisanite	M.A. 1-347
1·953	Kernite	M.A. 3-272
1·98	Racewinite	M.A. 1-23
1·998	Al-phosphate	M.A. 1-262
1·999	Delvauxite	M.A. 2-142
2·004	Cryptohalite	M.A. 3-309
2·02	Meerschaum	T.A. 4
—	Boothite (calc.)	M.A. 1-348
—	Zn-Cu-Melanterite	M.A. 1-121
2·045	Gmelinite	T.A. 5
2·05	Bolivarite	M.A. 1-378
2·06	Opal	M.A. 2-430
—	Gmelinite	M.M. 17-297
2·07	,,	M.M. 17-297
2·074	Monoclinic sulphur	M.A. 1-64
2·08	Opal	M.A. 2-430
—	Fibroferrite	T.A. 3
2·087	Copiapite	M.A. 2-40
2·09	Chabazite	M.M. 17-297
—	Gmelinite	M.M. 17-297
—	Fibroferrite	T.A. 3

[1] H. S. Washington, Journ. Franklin Inst., 1920, vol. 190, p. 804 [Min. Abstr., vol. 1, p. 160].

2·090	Gmelinite .	. T.A. 5
2·10	Ptilolite .	M.A. 2–59
2·102	Flokite = ptilolite	M.A. 1–24
2·105	Destinezite .	M.A. 2–142
2·11	Paternoite .	M.A. 1–150
2·116	Stilbite .	M.A. 3–349
2·12	Ptilolite .	M.A. 2–59
2·120	Meyerhofferite .	. T.A. 4
2·125	Mordenite .	M.A. 2–301
2·13	Opal .	M.A. 2–111
2·132	Kainite .	. T.A. 1
2·133	Chabazite .	M.A. 3–349
2·135	Gmelinite .	. T.A. 5
2·139	Kreuzbergite .	M.A. 1–125
2·14	Trona .	M.A. 2–47
2·148	Mordenite .	. T.A. 5
2·15	Stevensite .	M.A. 1–31
2·150	Ferrierite .	M.A. 1–26
2·152	Hydrogiobertite	. T.A. 1
—	Hydromagnesite	M.A. 2–320
—	Epidesmine .	. T.A. 4
2·16	,, .	. T.A. 4
—	Heulandite .	M.M. 15–378
—	,, .	M.M. 15–379
—	Hydromagnesite	M.A. 1–107
2·161	Stichtite .	. T.A. 4
2·162	Stilbite .	. T.A. 5
2·166	Halite .	. T.A. 5
2·168	Chabazite .	M.A. 2–118
2·17	Heulandite .	. T.A. 4
—	'Zeolite X' (art.)	. T.A. 5
2·172	Stilbite .	. T.A. 5
2·175	Chalcedony (ignited)	. T.A. 5
2·183	Natrolite .	. T.A. 5
2·193	Mordenite .	. T.A. 5
2·194	Zebedassite .	M.A. 1–25
—	Silica glass .	. T.A. 5
2·198	Scolecite .	M.A. 3–349
2·2	Analcime (art.)	. T.A. 5
2·20	Penwithite .	M.A. 3–214
—	Stevensite .	M.A. 1–31
2·201	Leonite .	. T.A. 1
2·206	Okenite .	M.A. 1–21
2·208	Silica glass .	. T.A. 6
2·21	Stilbite .	. T.A. 4
2·213	Silica glass .	. T.A. 5
2·215	Natrolite .	M.A. 2–118
2·216	Graphite .	. T.A. 1
—	Heulandite .	. T.A. 5
—	Glaucochroite .	. T.A. 1
2·218	Heulandite .	M.A. 3–349
2·219	Analcime .	. T.A. 3
2·22	Opal . .	M.A. 1–139
—	Crestmoreite .	. T.A. 5
—	Thomsonite .	. T.A. 6
2·223	Analcime .	. T.A. 3
2·227	,, .	. T.A. 5
2·228	Scolecite .	M.A. 3–349
2·231	Analcime .	. T.A. 3
2·235	Epinatrolite .	. T.A. 2
2·239	Natrolite .	M.A. 2–118
—	Analcime .	. T.A. 5
2·24	,, .	. T.A. 4
—	Epinatrolite .	. T.A. 2
2·244	Analcime .	M.A. 2–58
2·248	Natrolite .	. T.A. 5
2·249	Heulandite .	. T.A. 4
2·25	Flint (ignited) .	. T.A. 5
—	Lucianite .	M.A. 1–255
—	Analcime .	. T.A. 2
2·252	Scolecite .	. T.A. 5
2·254	Analcime .	. T.A. 3
2·256	Thomsonite .	. T.A. 4
2·257	Analcime .	. T.A. 3
—	Mesolite .	. T.A. 5
2·26	Arduinite .	. T.A. 4
2·260	Analcime .	. T.A. 3
—	Mesolite .	. T.A. 5
2·265	Analcime .	. T.A. 2
2·267	Tridymite .	M.A. 2–160
2·27	,, .	. T.A. 5
—	α-Tridymite (art.)	. T.A. 5
2·270	Tridymite (art.)	. T.A. 4
2·272	Laumontite .	. T.A. 4
2·279	Scolecite .	M.A. 1–153
2·28	Oxalite .	. T.A. 1
—	'Zeolite A' (art.)	. T.A. 5
2·283	Laumontite .	. T.A. 5
2·285	,, .	M.A. 3–349
—	Analcime .	M.A. 2–58
2·29	Chalcoalumite .	M.A. 2–520
—	Nontronite .	. T.A. 4
2·290	,, .	. T.A. 4
2·291	Paravauxite .	M.A. 2–148
2·292	Pinnoite .	. T.A. 1
2·295	Sodalite .	M.A. 3–280
—	Nontronite .	. T.A. 4
2·299	Thomsonite .	. T.A. 5
2·30	Paravauxite .	. T.A. 5
—	Ptilolite .	M.A. 1–31
—	Sodalite .	M.A. 3–118
—	,, .	M.A. 3–280
2·302	Okenite .	M.A. 3–288
2·306	Kornelite .	M.A. 3–7
2·309	Griffithite .	M.A. 1–206
2·31	Apophyllite .	M.A. 15–382
2·313	γ-Spodumene .	. T.A. 3
2·317	β-Spodumene .	. T.A. 4
2·32	Bloedite .	. T.A. 1
—	Cristobalite (art.)	M.A. 3–165
—	Gypsum .	M.M. 16–138
—	'Zeolite A' (art.)	. T.A. 5
2·323	Apophyllite .	. T.A. 4
—	Okenite .	M.A. 2–59
2·325	Wavellite .	M.A. 1–112
—	Okenite .	M.A. 2–59
2·326	,, .	M.A. 2–59
2·33	Cristobalite .	. T.A. 5
—	,, (art.)	. T.A. 5
—	Sodalite .	M.A. 3–118

2·33	Toadstone-clay	M.M. 20-155
2·332	Okenite	M.A. 2-59
2·333	,,	T.A. 5
—	Cristobalite (art.)	T.A. 4
2·336	β-Spodumene	T.A. 4
2·339	Thomsonite	T.A. 5
2·34	Davyne	T.A. 4
—	Magnalite	M.A. 2-54
—	Thomsonite	T.A. 6
2·35	'Zeolite Y' (art.)	T.A. 5
—	Gyrolite	T.A. 1
2·350	Harmotome	M.A. 3-285
2·355	'Zeolite Z' (art.)	T.A. 5
2·36	Cristobalite	M.A. 2-411
—	Foshagite	M.A. 2-520
—	Hambergite	T.A. 4
2·365	Pseudo-eucryptite (art.)	T A 4
—	Harmotome	M.A. 3-285
2·369	Thomsonite	T.A. 4
2·37	Apophyllite	T.A. 2
—	,,	T.A. 4
2·373	β-Spodumene	T.A. 4
2·374	Löweite	T.A. 1
2·375	Vauxite	M.A. 2-148
2·377	Al-Na-Ca fluoride	T.A. 3
2·378	Thomsonite	T.A. 6
2·379	Apophyllite	T.A. 2
—	Thomsonite	M.A. 2-118
2·38	Brucite	T.A. 4
—	Jefferisite	M.A. 3-57
—	Kaolin	M.A. 3-15
2·385	β-Spodumene	T.A. 4
2·386	Chlorite	M.M. 21-76
—	Thomsonite	M.A. 3-286
—	,,	T.A. 6
2·388	Spodumene (fused)	T.A. 4
—	Gyrolite	M.A. 3-287
2·389	Thomsonite	T.A. 4
—	,,	T.A. 5
2·39	Brucite	T.A. 5
—	Petalite	M.M. 20-141
2·390	Gyrolite	M.A. 3-287
2·393	Chlorite	M.M. 21-76
2·394	Thomsonite	T.A. 4
2·396	Gyrolite	T.A. 4
—	Chlorite	M.M. 21-76
2·398	β-Spodumene	T.A. 4
2·4	Katangite	M.A. 1-250
—	Bauxite	M.A. 2-275
2·40	Gyrolite	T.A. 1
—	Hydronephelite	M.A. 3-302
2·400	Chrysocolla	T.A. 4
2·401	β-Spodumene	T.A. 4
2·405	Calcio-thomsonite	M.A. 2-361
2·408	Chrysocolla	T.A. 4
2·41	Cancrinite	T.A. 4
2·410	Petalite	T.A. 4
—	β-Spodumene	T.A. 3
2·411	,,	T.A. 4
2·412	,,	T.A. 4
2·414	Petalite	T.A. 4
2·417	Chrysocolla	T.A. 4
2·42	Heulandite	T.A. 5
—	Laumontite (β-leonhardite)	M.A. 2-178
2·425	Cancrinite	M.A. 3-303
—	Hydronephelite	M.A. 3-303
—	Paradoxite	M.A. 1-392
2·43	Cancrinite	T.A. 4
—	Priceite	M.A. 2-319
2·430	Paradoxite	M.A. 1-392
2·433	Priceite (pandermite)	M.A. 2-318
2·44	Halloysite	M.A. 1-67
—	Bentonite	M.A. 3-72
2·443	Sulphatic cancrinite	M.A. 1-256
2·45	Halloysite	M.A. 2-112
—	Searlesite	M.A. 2-319
—	Vauxite	T.A. 5
—	Radiophyllite	M.A. 2-341
2·457	Chrysotile	M.A. 3-100
—	Pascoite	T.A. 4
2·46	Cancrinite	T.A. 2
—	Davyne	M.A. 2-307
—	Ektropite	M.A. 1-19
—	Hydronephelite	M.A. 3-302
2·463	β-Spodumene	T.A. 4
2·47	Truscottite	M.A. 3-271
—	Variscite	T.A. 4
—	Cancrinite	T.A. 4
2·470	Bardolite	M.A. 2-343
2·48	Leucite (art.)	T.A. 5
2·482	Cancrinite	M.A. 3-118
2·487	Davyne	M.A. 3-364
2·49	Kaolin	M.A. 2-112
2·492	Davyne	M.A. 3-364
2·495	Ussingite	T.A. 4
2·498	Avogadrite	M.A. 3-238
2·5	Neotocite	T.A. 5
—	Sulphohalite	T.A. 4
—	Bauxite	M.A. 2-275
2·50	Hisingerite	M.A. 3-215
—	Marialite	M.A. 1-107
—	Uranospathite	M.M. 17-230
—	Allanite	M.A. 2-185
2·505	Avogadrite (art.)	M.A. 3-238
2·506	Marialite	T.A. 5
—	Scapolite	M.A. 2-220
2·51	Centrallasite	M.A. 3-217
—	Colerainite	M.A. 1-9
—	Leucite (art.)	T.A. 5
2·511	Metahewettite	T.A. 4
2·513	Carnegeite (art.)	T.A. 3
—	,,	M.A. 1-167
2·52	Epichlorite	M.M. 20-63
—	Lucinite	T.A. 4
2·524	Anauxite	M.A. 2-306
2·528	Nepheline (art.)	T.A. 5
—	Serpentine	M.A. 2-212
2·53	Radiophyllite	T.A. 6

2·53	Lucinite	T.A. 4
2·533	Titano-elpidite	M.A. 3-235
2·536	Orthoclase (calc.)	M.A. 2-374
2·54	Orthoclase	T.A. 5
—	Variscite	T.A. 3
—	μ-$CaCO_3$ (art.)	M.A. 1-166
—	Lithomarge	M.A. 2-135
—	Iddingsite	M.A. 3-121
2·545	Beryl	T.A. 5
2·548	Kaolin	M.A. 1-205
2·55	Chalcedony	M.A. 1-414
—	,,	T.A. 5
—	Orthoclase (art.)	T.A. 5
—	Serpentine	M.A. 2-112
—	Lithomarge	M.A. 2-135
—	Rivaite	T.A. 4
2·554	Hewettite	T.A. 4
—	Microcline	M.A. 2-125
2·558	Microcline-perthite	M.A. 3-155
2·56	Kaliophilite	T.A. 4
—	Lithidionite	T.A. 4
—	Microcline	T.A. 4
—	Microcline-microperthite	M.A. 2-112
—	Rivaite	T.A. 4
—	Variscite	M.A. 1-109
2·560	Marialite	T.A. 1
—	Titano-elpidite	M.A. 3-235
2·561	Orthoclase	T.A. 4
2·562	Microcline	T.A. 1
—	,,	M.A. 2-224
2·564	Orthoclase	T.A. 4
—	Sanidine	M.A. 2-223
2·565	Leifite	M.A. 1-123
2·566	Microcline	M.A. 2-305
2·568	Sanidine	T.A. 3
—	,,	T.A. 4
2·57	Adularia	T.A. 4
—	Chalcedony	M.A. 1-414
—	Chrysotile	T.A. 5
—	Hörnesite	T.A. 5
—	Microcline-microperthite	M.A. 2-112
—	Microcline	M.A. 2-125
—	Variscite	M.A. 1-109
2·570	Adularia	M.A. 1-90
2·571	Cordierite	T.A. 4
—	Natron-sanidine	T.A. 1
2·573	Kieserite	T.A. 1
2·575	Sanidine	T.A. 5
2·576	Microcline (amazonite)	T.A. 1
2·578	Leifite	M.A. 1-123
2·579	Microcline	T.A. 4
—	Syngenite	T.A. 4
2·58	Kaolin	M.A. 3-15
—	Anorthoclase	T.A. 4
—	Serpentine	M.A. 3-207
2·581	Cordierite	T.A. 4
2·582	'Killinite'	M.A. 3-216
	Orthoclase	M.A. 1-90
2·582	Sanidine	T.A. 4
2·584	Anorthoclase	T.A. 4
2·585	Cordierite	T.A. 4
2·59	Anorthoclase	M.A. 2-76
—	Bertrandite	M.M. 17-17
—	Kämmererite	M.A. 3-57
—	Nepheline	M.A. 3-364
—	Kaolin	T.A. 6
2·590	Parsettensite	M.A. 2-251
2·592	Microperthite	T.A. 2
2·593	Cordierite	T.A. 1
2·595	Microcline	T.A. 5
—	Microcline-microperthite	M.A. 1-90
—	Microperthite	T.A. 4
2·597	Bertrandite	T.A. 2
2·598	Cordierite	M.M. 20-248
2·6	Beryl	T.A. 5
—	Ferronatrite	T.A. 5
—	Collophane	M.A. 1-413
2·60	Bertrandite	M.A. 2-112
—	Camsellite	M.A. 2-565
—	Cordierite	M.A. 1-67
—	Mizzonite	T.A. 1
—	Nepheline	T.A. 4
—	Radiophyllite	M.A. 2-341
—	Anorthoclase	T.A. 4
—	Prochlorite	T.A. 6
2·600	Cordierite	T.A. 4
—	Orthoclase (moonstone)	M.A. 1-134
2·602	Anorthoclase	M.M. 20-336
2·603	Albite	M.A. 2-400
—	Cordierite	T.A. 4
2·604	Bertrandite	T.A. 2
2·605	Cordierite	T.A. 4
—	Albite	M.A. 2-435
—	Anorthoclase	M.M. 20-336
2·606	Albite-oligoclase	T.A. 6
—	Anorthoclase	M.A. 1-90
2·61	Kaliophilite	M.A. 3-364
—	Chalcedony	T.A. 5
—	Serpentine	M.A. 3-207
—	Flint	T.A. 5
2·610	Albite	T.A. 4
—	Nepheline	M.A. 3-303
—	Scapolite	T.A. 4
2·611	Albite (calc.)	M.A. 2-374
2·612	Oligoclase	T.A. 5
—	Scapolite	M.A. 3-348
2·613	Albite	T.A. 4
—	Antigorite	M.A. 2-212
2·614	Ralstonite	T.A. 3
2·615	Potash-oligoclase	M.M. 20-332
2·616	Albite	T.A. 4
—	Beryl	T.A. 4
—	Marialite	T.A. 5
2·617	Avogadrite	M.A. 3-238
2·618	Albite	M.A. 2-435
2·619	Afwillite	M.M. 20-284

2·619	Albite	T.A. 4
—	Gajite	T.A. 2
—	Pennine	M.M. 16-266
—	Soda-nepheline (art.)	T.A. 3
—	,,	M.A. 1-167
2·62	Albite	T.A. 4
2·620	Potash-oligoclase	M.M. 20-332
—	Albite-oligoclase	T.A. 6
2·622	Albite	T.A. 4
—	,,	T.A. 5
—	Oligoclase	T.A. 5
2·623	Albite	M.A. 1-281
2·624	,,	M.A. 2-64
—	,,	T.A. 6
2·625	,,	M.A. 2-435
—	,,	M.A. 3-155
—	Potash-oligoclase	M.M. 20-332
—	Couzeranite	T.A. 1
2·626	Albite	T.A. 4
—	Beryl	T.A. 1
2·627	Albite	T.A. 6
2·628	Beryl	T.A. 4
2·629	Albite-oligoclase	T.A. 6
2·63	Albite	M.A. 3-292
—	Alunite	M.A. 1-379
—	Anorthoclase	T.A. 5
—	K-Na-felspar	M.A. 2-75
—	Chalcedony	T.A. 5
—	Flint	T.A. 5
2·630	Afwillite	M.M. 20-284
2·631	Oligoclase	M.A. 2-305
—	Albite	T.A. 6
2·632	Scapolite	T.A. 4
2·633	,,	M.A. 3-348
2·634	Albite	T.A. 6
2·638	Beryl	T.A. 4
—	Quartz sand	T.A. 6
2·639	Marialite	T.A. 5
2·64	Riversideite	T.A. 5
2·640	Oligoclase-albite	T.A. 2
2·644	Rhodochrome	M.A. 2-215
2·645	Beryl	M.A. 2-139
—	Nepheline	T.A. 5
2·646	Oligoclase	T.A. 5
—	,,	M.A. 3-292
2·647	Beryl	M.A. 2-139
—	Nepheline	T.A. 5
2·648	Leuchtenbergite	M.A. 2-213
—	Emerald	M.A. 3-298
2·649	Quartz	T.A. 2
2·65	Leuchtenbergite	M.A. 2-215
—	Lublinite	T.A. 4
—	Mn-silicate	M.A. 1-389
—	Nepheline	M.A. 1-108
—	Potash-nepheline (art.)	T.A. 3
—	Quartz	T.A. 5
—	Patronite	T.A. 1
2·651	Quartz	M.A. 2-374
2·652	Beryl	M.A. 2-139
—	Nepheline	T.A. 5
2·653	Oligoclase	T.A. 5
2·654	Quartz	T.A. 4
2·655	Xonotlite	M.A. 2-531
2·657	Clinochlore	M.A. 3-57
2·658	α-Catapleiite	M.A. 2-385
—	Scapolite	M.A. 3-348
2·659	Leuchtenbergite	M.A. 2-213
—	Pyrophyllite	T.A. 4
2·66	Oligoclase	T.A. 4
2·660	Cordierite	T A. 4
—	Scapolite	T.A. 1
2·661	Beryl	M.A. 3-310
—	Pennine	M.A. 2-215
2·662	Scapolite	M.A. 3-348
2·663	Andesine	M.A. 3 35
2·664	Beryl	M.A. 1-111
—	Nepheline	M.A. 3-118
2·665	Andesine	T.A. 5
2·666	Rumpfite	T.A. 2
2·667	Eucryptite	T.A. 4
—	Andesine	T A. 5
2·668	,,	M.A. 3-35
2·669	Beryl	T.A. 4
2·67	Alunite	M.A. 1-378
—	Andesine	M.A. 1-281
—	Beryl	M.A. 2-287
—	Kämmererite	M.A. 3-57
—	Prochlorite	M.A. 3-56
—	Scapolite	M.A. 1-12
—	Thenardite	M.A. 2-562
2·671	Andesine	T.A. 5
—	Beryl	T.A. 4
—	Ekmannite	M.A. 2-476
2·672	Oligoclase	T.A. 4
—	Marialite	T.A 5
2·673	Clinochlore	M.A. 3-57
—	Andesine	T.A. 5
2·674	$Ab_{35}An_{65}$ (art.)	T.A. 1
—	Beryl	T.A. 4
2·675	Andesine	M A. 3-79
—	Beryl	T.A. 4
2·676	,,	T.A. 4
—	Scapolite	T.A. 1
—	,,	M.A. 3-348
—	Al-Na-fluoride	T.A. 3
2·678	Allanite	T.A. 4
—	Vivianite	M.A. 3-50
2·679	Beryl	T.A. 4
—	Clinochlore	M.A. 2-215
2·68	Albite	T.A. 4
—	Allanite	T.A. 4
—	Beryl	M.A. 1-332
—	Pseudonepheline	T.A. 1
—	Scapolite	M.A. 2-178
2·681	Parsettensite (errite)	M.A. 2-251
2·682	Pennine	M.A. 2-215
—	Anorthite (fused)	T.A. 4
2·683	,, ,,	T.A. 4
2·684	Anemousite	T.A. 1

2·685	Beryl	T.A. 4
—	Eakleite	M.A. 1–206
2·686	Labradorite	M.A. 3–292
2·688	Albite	T.A. 4
—	Scapolite	T.A. 5
2·689	Labradorite	T.A. 5
—	Beryl	T.A. 4
—	,,	T.A. 3
2·69	Allanite	T.A. 4
—	Ascharite	T.A. 1
—	Labradorite	T.A. 4
—	Lanthanite	T.A. 1
2·690	Labradorite	T.A. 4
2·692	Beryl	T.A. 3
—	Scapolite	M.A. 3–348
—	,,	M.A. 2–220
—	Marialite	T.A. 5
—	Biotite	T.A. 4
2·693	Beryl	T.A. 3
—	,,	M.A. 2–139
—	Labradorite	T.A. 5
—	Pseudophite	M.M. 20–242
—	Vivianite	M.A. 2–475
2·694	Beryl	T.A. 4
—	Emerald	M.A. 3–298
2·695	Labradorite	T.A. 4
—	Pseudophite	T.A. 6
2·697	Quartz	T.A. 4
—	Allanite	T.A. 4
—	Beryl	T.A. 4
2·698	,,	T.A. 4
—	Labradorite	T.A. 4
—	Scapolite	T.A. 5
—	,,	T.A. 4
2·699	Calcite	T.A. 5
2·7	Aphthitalite	T.A. 5
2·70	Calcite	M.A. 3–192
—	Glauconite	M.M. 19–330
—	Na-K-alunite	M.A. 3–206
—	$Ab_{25}An_{75}$ (art.)	T.A. 1
—	Scorodite	T.A. 6
2·701	Beryl	T.A. 4
—	,,	M.A. 3–310
2·702	,,	M.A. 2–139
—	Scapolite	T.A. 5
—	Sheridanite	T.A. 3
2·703	Beryl	T.A. 1
—	,,	T.A. 3
—	Anorthite	T.A. 1
2·705	Beryl	M.A. 2–139
—	Eakleite	M.A. 1–206
—	,,	T.A. 5
—	Labradorite	T.A. 5
—	,,	T.A. 6
2·706	Beryl	T.A. 4
—	Labradorite	M.M. 16–269
2·708	$Ab_{20}An_{80}$ (art.)	T.A. 1
2·709	Emerald	M.A. 3–298
—	Beryl	T.A. 3
2·71	Patronite	T.A. 1
2·710	$Ab_{15}An_{85}$ (art.)	T.A. 1
—	Gearksutite	M.M. 19–32
—	Scapolite	T.A. 4
—	Beryl	T.A. 3
2·711	Scapolite	M.A. 2–126
—	Beryl	T.A. 1
—	,,	T.A. 3
2·712	,,	T.A. 3
—	,,	T.A. 4
—	$Ab_{42·5}An_{57·5}$	M.A. 2–433
2·713	Beryl	T.A. 3
—	,,	T.A. 1
—	Creedite	M.A. 1–417
—	Calcite	T.A. 4
—	Scapolite	T.A. 1
2·714	Beryl	T.A. 1
—	Halloysite	T.A. 5
—	Myeline	M.A. 1–264
—	$Ab_{12·5}An_{87·5}$ (art.)	T.A. 1
—	Beryl	T.A. 3
2·715	,,	T.A. 3
—	Gearksutite	M.M. 19–32
—	Scapolite	M.A. 2–267
2·716	,,	T.A. 5
—	Beryl	T.A. 3
—	,,	T.A. 1
2·717	,,	T.A. 3
—	Calcite	T.A. 5
2·718	Beryl	T.A. 3
—	,,	T.A. 4
—	,,	T.A. 2
—	,,	T.A. 1
—	Labradorite	T.A. 1
2·719	Beryl	T.A. 1
—	,,	T.A. 2
—	,,	T.A. 3
—	Scapolite	T.A. 4
2·72	Calcite	M.A. 3–266
—	Phosphorite	M.A. 2–92
2·720	Calcite	T.A. 5
—	Beryl	T.A. 3
—	,,	T.A. 4
—	Gearksutite	M.M. 19–32
—	Scapolite	T.A. 4
2·721	Anorthite (cyclopite)	M.A. 2–62
—	Beryl	T.A. 3
2·722	,,	T.A. 3
—	Scapolite	T.A. 5
—	$Ab_{10}An_{90}$ (art.)	T.A. 1
—	Calcite	T.A. 4
2·724	Allanite	T.A. 4
—	Calcite	T.A. 5
2·725	Beryl	T.A. 4
—	,,	M.A. 1–76
2·726	Alunite	M.A. 3–56
—	Phosphosiderite?	M.A. 1–417
2·727	Beryl	T.A. 4
2·729	Anorthite	T.A. 1
—	Scapolite	T.A. 5

2·729	Beryl	T.A. 3
2·73	„	T.A. 1
—	Calcite (plumbocalcite)	T.A. 5
—	Dolomite-rock	M.A. 1–75
—	Glauconite	M.A. 1–419
2·730	Creedite	M.A. 1–205
—	Scapolite	T.A. 4
2·731	Beryl	T.A. 3
2·732	„	T.A. 3
2·735	Leuchtenbergite	M.A. 3–57
2·736	Beryl	T.A. 4
—	Pectolite	M.A. 3–25
—	Scapolite	T.A. 1
2·737	Phlogopite	M.A. 3–82
—	Beryl	T.A. 3
2·738	„	T.A. 1
—	„	T.A. 3
2·739	„	T.A. 4
2·74	„	T.A. 4
—	Scapolite	M.A. 2–220
—	Lanthanite	T.A. 1
2·740	Beryl	T.A. 4
—	Ab_6An_{95} (art.)	T.A. 1
2·741	Allanite	T.A. 4
—	Scapolite	T.A. 5
—	Calcite	T.A. 4
2·742	Beryl	T.A. 3
—	Scapolite	T.A. 5
2·743	Beryl	T.A. 3
—	Manganophyllite	M.A. 2–424
2·744	Anorthite	T.A. 5
—	Calcite	T.A. 5
2·745	Beryl	T.A. 3
2·746	Anorthite	T.A. 5
—	Beryl	T.A. 3
2·748	„	T.A. 1
—	„	T.A. 3
—	Sulphate-scapolite	M.A. 1–284
2·749	Beryl	T.A. 4
2·75	„	T.A. 2
—	Emerald	M.A. 2–5
—	Jurupaite	M.A. 1–254
—	Phlogopite	M.A. 2–126
2·750	Scapolite	T.A. 5
—	Beryl	T.A. 4
2·751	„	T.A. 4
2·752	Anorthite (calc.)	M.A. 2–374
—	Beryl	T.A. 3
2·754	Anorthite (art.)	T.A. 1
2·755	Calcite	T.A. 5
—	Sulphate-scapolite	M.A. 1–284
2·757	Anorthite	T.A. 4
2·758	„	T.A. 4
—	Beryl	T.A. 3
2·76	Szajbelyite	M.A. 3–316
2·760	Anorthite	M.A. 1–281
—	Manganophyllite	M.A. 2–424
2·761	Pectolite	M.A. 3–25
2·762	Anorthite	T.A. 5
2·763	„	T.A. 5
2·764	Beryl	T.A. 3
—	Scapolite	T.A. 5
2·765	Beryl	T.A. 3
2·768	Gearksutite	M.A. 1–205
—	Sulphate-scapolite	T.A. 5
2·769	Calcite	T.A. 4
2·77	average for earth's crust	M.A. 1–160
—	Allanite	T.A. 4
—	Amesite	M.A. 1–71
—	Diabantite	M.A. 1–171
2·770	Beryl	T.A. 3
2·771	Sulphate-scapolite	T.A. 5
2·772	„	T.A. 5
—	Beryl	T.A. 3
2·774	Cryolithionite	T.A. 3
2·775	Beryl	T.A. 3
2·78	Sulphate-scapolite	T.A. 5
—	Bentonite	M.A. 3–72
2·780	Pinite	M.A. 1–422
2·782	Beryl	T.A. 3
2·783	Hydrophlogopite	T.A. 6
2·784	Beryl	T.A. 3
2·785	„	T.A. 1
—	Diabantite	T.A. 5
2·786	Phlogopite	T.A. 6
2·787	Clinochlore	M.A. 2–215
—	Manganophyllite	M.A. 2–424
2·79	Beryl	T.A. 1
—	Biotite	M.A. 2–112
—	Diabantite	M.M. 20–152
—	Pectolite	M.A. 1–398
2·791	Phlogopite (calc.)	M.A. 2–425
2·792	Dolomite	T.A. 5
—	Phlogopite	T.A. 6
2·793	Manganophyllite	M.A. 2–424
2·797	Muscovite	T.A. 6
2·798	Sericite	M.M. 16–264
2·799	Lepidolite	T.A. 1
2·8	Limnite	M.M. 18–340
2·80	Bazzite	M.A. 1–204
—	Beryl	T.A. 1
—	Iddingsite	M.A. 3–121
2·800	Beryl	T.A. 3
2·801	Lepidolite (calc.)	M.A. 2–425
2·802	Muscovite (calc.)	M.A. 2–425
2·803	Muscovite	T.A. 4
—	Tabergite	M.A. 2–215
—	Lepidolite	T.A. 1
2·806	Beryl	T.A. 3
2·808	„	T.A. 3
2·809	Muscovite	M.A. 3–356
2·81	Beryl	T.A. 2
—	Manganocalcite	M.A. 2–360
—	Phlogopite	MA. 2–126
2·812	Beryl	T.A. 3
2·815	Meionite	T.A. 1
2·816	Muscovite	T.A. 4
—	Phlogopite	T.A. 6
2·819	Allanite	T.A. 4

2·819	Huronite	M.A. 2-238
2·82	Beryl	T.A. 1
—	Calcite	T.A. 5
—	Glauconite	M.A. 1-419
2·820	Beryl	T.A. 3
—	Lepidolite	T.A. 6
2·821	Muscovite	T.A. 6
2·829	Dolomite	M.A. 3-130
2·83	Muscovite	M.A. 3-214
2·831	Beryl	T.A. 4
—	Phlogopite	M.A. 3-82
2·832	Talc	T.A. 6
2·834	Pectolite	M.A. 2-528
—	Dolomite	T.A. 4
2·835	Beryl	T.A. 4
—	Muscovite	T.A. 6
2·837	Lepidolite	T.A. 6
2·838	Muscovite	T.A. 6
2·839	Phlogopite	T.A. 6
2·84	Beryl	M.A. 3-205
—	Eudialyte	M.A. 2-264
—	Sincosite	M.A. 2-381
—	Strengite	T.A. 4
—	Turquoise	T.A. 3
2·842	Lepidolite	M.A. 1-352
2·843	Muscovite	T.A. 6
2·844	Xanthoxenite	M.A. 1-125
2·846	Muscovite	M.A. 3-356
2·847	Beryl	T.A. 2
—	,,	T.A. 3
2·848	,,	T.A. 4
2·849	Dolomite	T.A. 5
2·85	,,	M.A. 1-75
—	Muscovite	M.A. 3-214
—	Stilpnomelane	M.M. 20-194
2·850	Muscovite	T.A. 6
—	Beraunite	T.A. 4
2·855	Muscovite	T.A. 6
2·856	,,	T.A. 6
2·857	Pectolite	M.A. 3-285
2·86	Beryl	T.A. 1
—	Eudialyte	M.A. 2-264
—	Minguetite	T.A. 1
—	Phosphorite	M.A. 2-92
—	Strengite	M.A. 1-417
—	'Rare-earth zeolite'	M.A. 2-263
—	Scorodite	T.A. 6
2·860	Dolomite	T.A. 4
2·861	Aragonite	M.A. 2-476
2·863	Monetite	M.A. 3-126
2·865	Dolomite	T.A. 4
—	,,	T.A. 5
—	Manganophyllite	M.A. 2-424
—	Dolomite	T.A. 4
2·867	,,	T.A. 5
2·868	,,	T.A. 5
—	,,	T.A. 4
2·869	,,	T.A. 5
—	Lepidolite	M.A. 2-401
2·869	Phlogopite	M.A. 3-82
2·87	Dolomite	T.A. 5
—	Soumansite	T.A. 1
2·870	Beryl	T.A. 4
—	Prochlorite	M.A. 3-25
2·872	Damourite	M.A. 3-155
—	Dolomite	T.A. 5
2·875	Muscovite	T.A. 6
—	Prehnite	T.A. 5
2·876	Muscovite	T.A. 6
2·88	Dolomite	M.A. 1-75
—	Prehnite	M.M. 16-217
—	Salmonsite	T.A. 3
2·880	Beryl	T.A. 1
—	,,	T.A. 3
2·881	Corundophyllite	M.A. 2-215
—	Lepidolite	T.A. 6
—	Beryl	T.A. 3
—	Dolomite	T.A. 5
2·882	,,	M.A. 1-350
—	Stilpnomelane	M.A. 2-568
—	Muscovite	T.A. 4
2·883	,,	T.A. 6
2·884	Prehnite	T.A. 5
2·885	Ferrisymplesite	M.A. 2-382
—	Fe-muscovite (calc.)	M.A. 2-425
2·886	Beryl	T.A. 4
2·887	Dolomite	T.A. 5
—	,,	T.A. 4
2·889	,,	T.A. 5
2·89	,,	T.A. 5
—	Fluoborite	M.A. 3-110
—	Prehnite	T.A. 4
—	Viridite	M.A. 1-255
—	Boracite (stassfurtite)	T.A. 1
2·890	Dolomite	T.A. 4
—	,,	T.A. 5
2·891	,,	T.A. 4
—	Muscovite	T.A. 4
2·897	Biotite	T.A. 6
—	Manganophyllite	M.A. 2-424
—	Wollastonite	T.A. 5
2·9	Collophane	M.A. 1-413
2·90	Dolomite	M.A. 1-75
—	Hyalophane	M.A. 3-312
—	Prochlorite	T.A. 6
—	Beraunite	T.A. 4
2·900	Dolomite	M.A. 3-59
—	Prehnite	M.A. 3-285
2·901	Dolomite	T.A. 5
2·904	Aragonite	M.M. 20-417
—	Prehnite	T.A. 5
2·906	,,	M.A. 1-48
2·907	Annabergite	M.A. 2-382
—	Dolomite	T.A. 4
2·91	Custerite	T.A. 4
—	Dolomite	T.A. 5
—	Boracite (stassfurtite)	T.A. 1
—	Beraunite	T.A. 4

2·910	Beryl	T.A. 3
2·912	Wollastonite (art.)	T.A. 4
—	Dolomite	T.A. 5
2·913	Actinolite	T.A. 4
2·914	Prehnite	M.A. 1-48
—	Dolomite	T.A. 4
2·916	Prehnite	M.A. 3-49
—	Roscherite	T.A. 4
—	Zinnwaldite	M.A. 2-401
2·918	Prehnite	T.A. 4
2·92	Humboldtilite	T.A. 5
2·920	Beraunite	T.A. 4
2·922	Aragonite	M.M. 20-417
2·925	Humboldtilite	T.A. 5
2·927	Kochite	T.A. 6
2·928	Prehnite	T.A. 1
2·929	Kochite	M.A. 2-51
—	Melilite	M.A. 2-165
2·93	Danburite	M.A. 2-469
2·932	Kochite	T.A. 6
2·936	Prochlorite	M.A. 2-214
2·938	Nephrite	M.A. 2-67
2·94	Kempite	M.A. 2-338
—	Stewartite	T.A. 3
2·943	Prehnite	M.A. 2-215
2·944	Åkermanite (art.)	M.A. 1-168
—	Phenakite	T.A. 5
2·95	Anthophyllite	T.A. 3
—	Magnesite	M.A. 1-15
—	Humboldtilite	T.A. 5
—	Biotite	M.A. 1-71
2·953	Manganophyllite	M.A. 2-424
2·954	Magnesite	M.A. 1-333
—	Manganophyllite	M.A. 2-424
2·957	Melilite	T.A. 4
2·958	Lazulite	T.A. 4
—	,,	M.A. 1-377
2·959	Aphrosiderite	M.A. 1-206
2·96	Cebollite	T.A. 4
—	Dolomite	T.A. 4
—	Nocerite	M.A. 1-107
—	Fe-Reddingite	M.A. 3-274
2·963	Allanite	T.A. 4
—	Biotite	M.A. 2-162
2·964	Allanite	T.A. 4
2·965	Cuspidine	T.A. 1
2·969	Gehlenite-åkermanite (art.)	T.A. 5
2·97	Amphibole-asbestos	M.A. 2-429
—	Eucolite	T.A. 4
—	Cuspidine	T.A. 4
—	Phenakite	M.A. 1-296
—	Zinnwaldite (calc.)	M.A. 2-425
—	Fluorite	M.A. 1-106
2·970	Zinnwaldite	T.A. 6
2·973	Lithionite	T.A. 1
2·974	Danburite	M.A. 2-67
—	Grodnolite	M.A. 2-343
2·975	Humboldtilite	T.A. 5
2·975	Ripidolite	T.A. 4
2·976	Pachnolite	T.A. 3
2·978	Tourmaline	T.A. 1
2·98	Justite	M.A. 2-22
—	Phenakite	M.M. 16-55
—	,,	M.M. 16-59
—	Fluorite	M.A. 1-107
2·980	Åkermanite	T.A. 5
2·981	Anhydrite	M.A. 2-356
—	Biotite	T.A. 6
2·982	Thomsenolite	T.A. 3
2·985	Asbolane	M.A. 3-264
2·987	Zinnwaldite	T.A. 6
2·989	Amblygonite	M.A. 2-400
—	Cuspidine	T.A. 1
2·99	Ankerite	T.A. 4
—	Beraunite	M.M. 21-275
—	Ferrimolybdite	M.A. 3-131
—	Nephrite	T.A. 4
2·991	Ankerite	T.A. 5
2·992	Wollastonite	T.A. 6
2·993	Biotite	M.A. 2-162
—	Datolite	M.A. 2-353
—	Dolomite	T.A. 6
—	Gehlenite-åkermanite (art.)	T.A. 5
2·995	Chiolite	T.A. 3
—	Datolite	M.A. 2-529
2·997	Spodumene	T.A. 4
3·0	Ferrazite	M.A. 1-18
3·000	Dahllite	M.A. 1-174
3·001	Datolite	M.M. 15-413
3·005	Chiolite	T.A. 3
—	Tourmaline	T.A 1
3·008	Montebrasite	M.A. 1-76
3·01	Ankerite	M.M. 16-220
—	Magnesite	M.A. 1-15
—	Ankerite	M.M. 16-222
—	Natramblygonite	T.A. 3
3·012	Dahllite	T.A. 4
3·015	Tourmaline	T.A. 1
3·017	Allanite	T.A. 4
—	Aragonite	M.A. 1-140
3·018	Gehlenite-åkermanite (art.)	T.A. 5
—	Zinnwaldite	T.A. 6
3·02	Actinolite	T.A. 6
—	Gehlenite	T.A. 5
—	Imerinite	T.A. 1
—	Magnesite	M.A. 1-15
—	,,	M.A. 3-238
—	Manganolangbeinite (art.)	M.A. 2-383
3·020	Ankerite	T.A. 4
—	Tourmaline (rubellite)	T.A. 1
3·021	Biotite	T.A. 6
3·025	Ankerite	T.A. 5
3·028	Tourmaline	T.A. 4
3·029	Biotite	T.A. 4
—	Amblygonite	T.A. 5

3·029	Magnesite	T.A. 5
—	Inesite	M.A. 2-252
3·03	Tourmaline	T.A. 2
—	Inesite (agnolite)	M.A. 2-352
—	Hopeite	M.A. 1-6
—	Manganolangbeinite (art.)	M.A. 2-383
3·037	Diopside	T.A. 6
3·038	Gehlenite (art.)	M.A. 1-167
—	Velardeñite (art.)	T.A. 4
3·039	Amblygonite	T.A. 5
—	Gehlenite	T.A. 5
—	Velardeñite	T.A. 4
3·04	Monticellite (art.)	M.A. 1-317
—	Tourmaline	T.A. 3
—	Xanthitane	M.A. 2-113
3·041	Phenakite	T.A. 4
3·042	Amblygonite	T.A. 5
3·047	Tourmaline	T.A. 1
3·048	Actinolite	M.A. 2-212
—	Tourmaline (rubellite)	T.A. 1
3·049	Amblygonite	T.A. 5
3·05	Allanite	T.A. 4
—	Ankerite	T.A. 3
—	Euclase	M.M. 20-189
—	Magnesite	T.A. 5
—	Orientite	M.A. 1-202
—	Tourmaline	T.A. 3
3·052	Magnesite	M.A. 2-239
3·053	Tourmaline	T.A. 3
3·054	,,	T.A. 4
3·055	,,	T.A. 4
—	Amblygonite	T.A. 5
3·056	Magnesite	M.A. 1-351
3·059	Tourmaline	T.A. 4
3·06	Ankerite	M.A. 3-213
—	Nephrite	T.A. 4
—	Voelckerite	M.M. 17-159
—	Natramblygonite	T.A. 3
3·061	Tourmaline	T.A. 1
3·064	,,	T.A. 4
3·065	Amblygonite	M.A. 1-76
3·066	Biotite	M.A. 2-162
—	Tourmaline	T.A. 4
3·069	Pargasite	T.A. 5
3·07	Thuringite	M.A. 2-352
—	Tourmaline	M.M. 18-133
—	Biotite	M.A. 1-71
3·071	Magnesite	T.A. 4
3·072	Tourmaline	T.A. 1
3·078	Monticellite	T.A. 5
3·079	Actinolite	M.A. 2-305
—	Biotite	T.A. 6
—	Grothine	M.A. 1-107
3·08	Ankerite	M.A. 3-262
3·080	Allanite	T.A. 4
3·081	Phosphophyllite	M.A. 1-125
—	Xanthophyllite	T.A. 4
3·082	Volgerite	M.A. 1-354
—	Phosphophyllite	T.A. 5
3·085	Biotite	M.A. 3-82
3·086	Tourmaline	T.A. 4
3·089	Pargasite (ignited)	T.A. 5
—	Tourmaline	T.A. 3
3·09	Arakawaite	M.A. 1-251
—	Euclase	T.A. 4
—	Magnesite	T.A. 5
3·090	Grothine	M.A. 1-107
—	Dahllite	T.A. 4
3·093	Clintonite	T.A. 5
3·094	Tourmaline	M.A. 2-359
—	Dahllite	M.A. 1-174
3·097	Amblygonite	T.A. 5
3·10	Bassetite	M.M. 17-224
—	Magnesite	T.A. 5
—	Merrillite	M.A. 2-560
—	Voelckerite	M.M. 17-157
—	Fe-Reddingite	M.A. 2-274
—	Fibrolite (art.)	T.A. 4
3·100	Tourmaline	M.A. 2-359
3·101	Amblygonite	M.A. 1-76
3·102	Tourmaline	T.A. 1
3·105	Ankerite	T.A. 4
3·106	Bementite	M.A. 1-176
—	Tourmaline	T.A. 1
3·107	Biotite	T.A. 6
3·11	Ankerite	T.A. 5
—	Magnesite	M.A. 2-430
—	Natrojarosite	M.A. 1-355
—	Tourmaline	T.A. 3
3·111	,,	T.A. 1
3·118	Andalusite	T.A. 4
—	Uralite	T.A. 4
3·119	Tourmaline	T.A. 4
3·12	Lawsonite	T.A. 4
—	Magnesite	T.A. 5
—	Tourmaline	T.A. 3
3·120	,,	T.A. 4
3·121	Ankerite	T.A. 5
3·123	Spencerite	M.A. 1-5
3·125	Biotite	T.A. 6
3·126	Lacroixite	T.A. 4
3·127	Tourmaline	T.A. 1
3·128	Heterogenite	M.A. 1-243
3·129	Plazolite	M.A. 1-151
3.13	Fluosiderite	M.A. 1-107
—	Hornblende	T.A. 6
—	Norbergite	M.A. 3-110
3·138	Anthophyllite	M.A. 2-212
3·14	Svanbergite	T.A. 5
—	Chlor-apatite (art.)	T.A. 4
—	Palaite	T.A. 3
3·142	Spencerite	M.M. 18-78
3·144	Tourmaline	T.A. 4
3·145	Spencerite	M.M. 18-78
3·147	Spodumene	T.A. 3
3·148	Protolithionite	T.A. 6
3·149	Erythrite-annabergite	M.A. 2-382
3·15	Tourmaline	T.A. 4

3·15	Aragonite (tarnowitzite)	M.A. 2-116
—	Fibrolite (art.)	T.A. 4
—	Norbergite	M.A. 3-110
—	Chlor-apatite (art.)	T.A. 4
3·150	Merwinite	M.A. 1-254
3·151	Apatite	T.A. 1
—	Lepidomelane	T.A. 6
—	Tourmaline	T.A. 4
3·153	Torendrikite	T.A. 5
3·154	Andalusite	M.A. 1-396
—	Spodumene	T.A. 4
3·156	Phosphoferrite	M.A. 1-125
3·157	Allanite	T.A. 4
3·16	Biotite	T.A. 1
—	Harstigite	T.A. 5
—	Lepidomelane	M.A. 3-303
—	Tourmaline	T.A. 3
—	Spodumene	T.A. 4
3·162	Andalusite	M.A. 1-396
3·167	Spodumene	M.A. 3-216
3·168	α-Spodumene	T.A. 3
3·169	Tourmaline	T.A. 1
3·17	Jarosite	M.A. 2-113
—	Johnstrupite	M.A. 2-263
—	Sellaite	T.A. 5
3·170	Allanite	T.A. 4
3·172	Fibrolite (bucholzite)	M.A. 1-213
3·175	Chondrodite	T.A. 5
3·177	Tourmaline	T.A. 1
3·178	Hornblende	M.M. 20-239
—	Lepidomelane	T.A. 6
3·18	Pababudanite	T.A. 2
—	Fluor-apatite	T.A. 3
—	Spodumene (art.)	M.A. 3-191
—	Spodumene	T.A. 4
3·180	Fluorite	M.A. 1-108
—	Fibrolite (bucholzite)	M.A. 1-213
3·181	Pargasite	T.A. 5
3·184	Apatite	M.A. 3-303
3·185	Andalusite	T.A. 4
3·186	Spodumene	T.A. 4
3·187	Tourmaline	T.A. 1
—	Epidote	M.A. 1-48
3·189	,,	M.A. 1-48
3·19	Allanite	T.A. 4
—	Ankerite	T.A. 4
—	Ludlamite (lehnerite)	M.A. 3-10
—	Weibyeite	M.A. 1-204
3·190	Calc-olivine	T.A. 4
3·191	Fluorite	M.A. 2-353
3·194	Akrochordite	M.A. 2-51
—	Fluor-apatite	T.A. 4
3·195	Fluorite	M.A. 1-108
3·196	Sulphate-apatite	M.A. 1-256
3·198	Autunite	M.A. 3-296
—	Hornblende	T.A. 1
3·2	Fibrolite	T.A. 4
—	Pumpellyite	M.A. 3-8
3·20	Bavalite	M.A. 2-184
—	Chlor-apatite	M.A. 2-560
—	Crocidolite	T.A. 4
—	Monticellite (art.)	M.M. 19-194
—	Palaite	T.A. 3
3·201	Fluorite	T.A. 2
—	Diopside	T.A. 6
—	Apatite	T.A. 4
3·202	Viridine	T.A. 5
3·203	Mangan-neptunite	M.A. 3-103
3·204	Spodumene	T.A. 4
3·206	Fluor-apatite	M.A. 1-351
3·207	Hornblende	T.A. 1
—	Sulphate-apatite	M.A. 1-256
3·208	Bronzite	M.A. 2-212
3·209	Fibrolite	M.A. 2-237
3·21	Parahopeite	M.A. 1-7
—	Torendrikite	M.A. 1-376
3·211	Allanite	T.A. 4
3·212	Clinozoisite	M.A. 3-218
—	Hornblende	T.A. 1
3·213	Hibbenite	M.A. 1-5
—	Hornblende	M.A. 2-66
—	,,	T.A. 4
3·214	Apatite	T.A. 3
3·216	Forsterite (art.)	T.A. 4
3·218	Apatite	T.A. 3
3·219	Torbernite	M.M. 19-45
3·22	Axinite	M.A. 2-354
—	Parahopeite	T.A. 5
—	,,	M.A. 1-7
—	Forsterite	M.A. 3-280
—	Tourmaline	T.A. 3
3·220	Viridine	M.A. 1-396
3·221	Axinite	M.A. 2-237
3·223	Hornblende	T.A. 1
3·223	,,	T.A. 4
3·224	,,	T.A. 4
3·225	,,	M.A. 2-224
3·226	,,	T.A. 4
—	Grossular	T.A. 4
3·229	Hornblende	T.A. 1
3·23	Allanite	T.A. 4
—	Cummingtonite	M.A. 3-153
—	Epidote (fouqueite)	M.A. 2-410
—	Fibrolite	M.M. 19-110
—	Forsterite	M.A. 1-93
3·231	Fluotaramite	M.A. 3-109
—	Hornblende	T.A. 1
3·234	Wilkeite	T.A. 4
3·235	Hornblende	T.A. 1
—	Scorodite	T.A. 4
3·236	Diopside	T.A. 5
—	Fluor-diopside	T.A. 5
—	Parahopeite	M.A. 1-7
—	Pyroxene	M.A. 2-68
—	Hornblende	T.A. 4
3·238	Viridine	T.A. 5

3·24	Ferro-anthophyllite	M.A. 1–253
—	Melilite (justite)	M.A. 2–22
3·240	Allanite	T.A. 4
—	Gedrite	T.A. 4
3·242	Augite	M.A. 1–161
3·243	,,	M.A. 1–283
3·25	Axinite	T.A. 4
—	Chlorite	M.A. 1–137
—	Fibrolite	M.M. 19–109
—	Rancieite	M.A. 2–144
3·250	Allanite	T.A. 4
—	Tourmaline	T.A. 4
3·252	Fibrolite	M.M. 19–109
—	Sursassite	M.A. 3–272
3·254	Enstatite	M.A. 2–305
3·255	Fibrolite	M.M. 19–109
3·257	Mangan-apatite	M.A. 2–401
3·26	Acmite-augite	M.A. 1–107
—	Diopside	T.A. 4
—	,,	M.A. 1–250
3·262	Spodumene	T.A. 4
3·265	Diopside	T.A. 5
3·266	Fibrolite	M.A. 3–280
—	Hornblende	T.A. 4
3·267	Diopside	M.A. 1–9
—	Fluotaramite	M.A. 3–109
3·268	Forsterite	M.A. 2–212
3·27	Augite	M.A. 1–93
—	Hornblende	T.A. 6
—	Plancheite	M.A. 1–416
3·270	Apatite	T.A. 5
—	Diopside-jadeite	M.A. 1–382
3·272	Diopside	M.A. 2–38
3·274	Aurichalcite	T.A. 4
—	Axinite	M.A. 3–306
3·275	Diopside	M.A. 2–38
3·276	Hornblende	M.A. 2–429
3·278	Diopside	M.A. 3–118
3·279	Allanite	M.A. 2–237
3·28	Zeunerite	M.A. 2–353
3·281	Diopside	T.A. 5
3·282	,,	T.A. 5
—	Kyanite	T.A. 4
3·286	Tinzenite	T.A. 6
3·287	Augite	T.A. 1
—	Diopside	T.A. 5
3·289	Helvine	M.A. 3–150
3·29	Andalusite	M.A. 3–51
—	Epidote	T.A. 3
3·290	Titanaugite	T.A. 4
3·291	Augite	M.M. 17–107
—	Diopside	T.A. 5
3·294	Lepidomelane	M.A. 3–303
3·295	Spodumene	T.A. 4
3·296	Axinite	M.A. 1–8
—	Dioptase	M.A. 1–350
3·298	Augite	T.A. 1
—	Barkevikite	T.A. 4
3·3	Aegirine	T.A. 4
—	Ferrazite	M.A. 1–18
3·30	β-Corundum (art.)	T.A. 4
—	Diopside	T.A. 4
—	,,	T.A. 6
—	Dumortierite	M.A. 3–315
—	Rancieite	M.A. 2–144
3·301	Allanite	T.A. 4
—	Olivine	M.A. 2–212
—	Spodumene	T.A. 4
3·303	Enstatite	M.A. 2–212
3·305	Protolithionite (calc.)	M.A. 2–425
3·307	Dioptase	T.A. 4
—	Johannite	M.A. 1–248
—	Olivine	T.A. 4
3·308	Fassaite	M.A. 2–69
3·309	Diopside	T.A. 5
—	Dumortierite	M.A. 2–39
—	Pyroxene	M.A. 2–68
3·31	Guarinite	T.A. 5
—	Omphacite	M.A. 1–163
3·311	Grünerite-cummingtonite	T.A. 6
3·312	Rhodochrosite	M.A. 2–143
3·313	Diopside	M.A. 2–38
—	Dioptase	T.A. 4
3·314	Axinite	M.A. 2–239
—	Bronzite	M.A. 2–160
3·315	,,	T.A. 4
3·318	Fluotaramite	M.A. 3–109
—	Dioptase	T.A. 4
—	Bronzite	T.A. 4
—	Augite	M.A. 2–65
3·319	Yttrofluorite	T.A. 4
3·32	Fe-Zn-Ca-olivine (art.)	T.A. 5
—	Idocrase	T.A. 5
—	Lovchorrite	M.A. 3–236
3·323	Pyroxene	T.A. 4
3·33	Allanite	T.A. 4
—	Buttgenbachite	M.A. 3–6
—	Gillespite	M.A. 1–375
—	Olivine	M.A. 2–436
—	Riebeckite	T.A. 4
3·330	Diopside-jadeite	T.A. 6
—	Augite	M.A. 2–65
3·331	Clinozoisite	T.A. 4
3·332	Pyroxene	T.A. 4
3·335	Soda-jadeite	M.A. 1–383
—	Grossular	M.A. 2–396
3·336	Idocrase	T.A. 5
—	Soda-jadeite	T.A. 5
3·337	Chrome-diopside	T.A. 4
—	Idocrase	M.A. 3–118
3·338	Augite	M.M. 19–179
—	Bronzite	T.A. 6
3·34	Augite	T.A. 6
—	Grünerite-cummingtonite	T.A. 6
—	Gerhardtite	T.A. 6
3·340	Lepidomelane (calc.)	M.A. 2–425

3·341	Calc-olivine	T.A. 4
3·343	Olivine	M.A. 3-58
—	Clinozoisite	M.A. 3-353
3·344	Rhodizite	T.A. 2
3·345	Prismatine	T.A. 1
3·346	Allanite	T.A. 4
3·348	Clinozoisite	M.A. 3-353
—	Ampangabeite	T.A. 4
3·349	Topaz	T.A. 4
3·35	Hornblende	T.A. 5
—	Zoisite	M.A. 2-215
3·351	Babingtonite	T.A. 4
—	Olivine	T.A. 5
—	Clinozoisite	M.A. 3-353
3·352	,,	M.A. 3-49
3·353	,,	M.A. 3-353
3·354	Hardystonite	M.A. 2-22
3·356	Clinozoisite	M.A. 3-49
3·358	Augite	M.A. 1-394
3·359	Babingtonite	M.A. 2-472
3·36	Dumortierite	T.A. 4
—	Hypersthene	T.A. 1
—	Idocrase	T.A. 5
3·360	Clinozoisite	M.A. 3-353
3·363	Allanite	T.A. 4
3·365	Chloromelanite	T.A. 6
—	Clinozoisite	M.A. 1-346
3·366	,,	M.A. 3-353
3·368	Schallerite	M.A. 2-420
3·369	Clinozoisite	M.A. 1-78
3·37	Plancheite	M.A. 3-265
3·371	Diopside	T.A. 6
—	Osannite	M.A. 2-401
3·373	Augite	M.A. 1-162
—	,,	M.A. 2-305
3·375	Clinozoisite	T.A. 4
—	Diopside	T.A. 6
—	Mesitite	T.A. 5
—	Clinozoisite	M.A. 1-109
3·376	,,	T.A. 4
3·379	,,	M.A. 1-78
3·38	Allanite	M.A. 3-208
3·380	Clinozoisite	M.A. 1-78
3·381	Augite	M.A. 2-433
—	Idocrase	T.A. 6
3·383	Clinozoisite	M.A. 1-78
3·385	,,	M.A. 1-78
—	Diaspore (tanatarite)	M.A. 3-237
—	Clinozoisite	M.A. 1-109
3·39	Allanite	T.A. 4
—	Grossular	T.A. 5
—	Lithiophilite	M.A. 3-131
—	Ti-augite	M.A. 1-394
—	Vogtite (art.)	M.M. 18-369
—	Augite	T.A. 6
3·391	Riebeckite	T.A. 2
3·395	Grünerite	T.A. 5
3·396	Allanite	T.A. 4
—	Grünerite	M.A. 1-253
3·396	Hastingsite	M.A. 3-400
3·398	Babingtonite	T.A. 4
3·4	Riebeckite	M.A. 1-277
3·40	Gerhardtite	M.A. 3-53
—	Rinkolite	M.A. 3-236
—	Augite	T.A. 6
3·401	Idocrase	T.A. 6
3·402	Augite	T.A. 1
3·404	Olivine	M.A. 3-58
—	Trimerite	M.A. 1-48
3·405	Yttrofluorite	T.A. 4
3·41	Allanite	T.A. 4
—	Idocrase	M.A. 2-240
—	Olivine	T.A. 5
3·411	Sphene	T.A. 5
3·414	Augite	T.A. 1
3·415	Hypersthene	M.A. 2-305
—	Idocrase	T.A. 4
3·416	Rhodonite	T.A. 6
—	Tinzenite	M.A. 2-252
3·417	Idocrase	T.A. 6
3·418	Uvarovite	T.A. 4
—	Ampangabeite	T.A. 4
3·42	Aegirine-augite (vanadiferous)	T.A. 4
—	Allanite	T.A. 4
—	Diopside	M.M. 16-277
—	,,	T.A. 5
—	Olivine	M.A. 1-108
3·420	Epidote	T.A. 4
3·421	Idocrase	T.A. 6
3·426	Hastingsite	M.A. 2-400
3·427	Allanite	T.A. 4
3·43	Ramsayite	M.A. 2-251
—	Olivine	T.A. 5
3·431	Sphene	T.A. 4
3·435	Augite	T.A. 1
—	Epidote	M.A. 1-109
3·439	Taramite	M.A. 3-109
—	Allanite	T.A. 4
3·44	,,	T.A. 4
—	Augite	M.M. 17-99
—	Riebeckite	M.A. 2-239
3·447	Epidote	T.A. 4
3·45	Chloritoid	M.A. 3-204
—	Sicklerite	T.A. 3
3·451	Idocrase	T.A. 1
3·456	Sphene	T.A. 5
3·46	Gerhardtite	T.A. 6
3·460	Sphene	T.A. 4
3·462	,,	T.A. 4
3·463	Glinkite	M.A. 2-212
3·47	Idocrase	M.A. 2-180
—	Ramsayite (art.)	M.A. 3-163
3·471	Olivine	M.A. 3-58
3·476	Taramite	M.A. 3-109
3·477	Melanovanadite	M.A. 1-250
3·48	Wöhlerite	M.A. 2-263
3·485	Epidote	M.A. 1-346
3·487	Aegirine	M.A. 3-303

3·49	Chrysoberyl .	M.A. 2-265
3·490	Allanite . .	T.A. 4
3·499	Aegirine . .	T.A. 2
—	Sphene . .	M.A. 2-429
—	,, . .	T.A. 6
3·5	Dufrenite . .	T.A. 5
3·50	Andradite. .	M.A. 3-207
—	Hedenbergite .	T.A. 3
3·506	Grossular . .	T.A. 4
3·507	Allanite . .	T.A. 4
—	Epidote . .	T.A. 4
3·509	Sphene . .	T.A. 4
3·510	Pyrope (calc.) .	T.A. 4
3·513	Diamond . .	M.A. 1-216
3·514	,, . .	T.A. 1
3·516	Dannemorite .	T.A. 6
3·518	Fermorite .	M.M. 16-85
—	Hornblende (barkevikite)	T.A. 5
3·52	Sphene . .	M.A. 1-379
—	Grossular . .	M.A. 2-396
3·525	,, . .	T.A. 4
3·530	,, (calc.) .	T.A. 4
3·531	Triphylite .	M.A. 2-471
3·532	Sphene . .	T.A. 6
3·536	Yttrofluorite .	T.A. 2
3·537	Sphene . .	T.A. 4
3·54	Ceruleofibrite = connellite	M.A. 2-10
—	Olivine . .	T.A. 6
—	Sklodowskite .	M.A. 2-341
—	,, .	M.A. 2-384
3·544	Diopside . .	T.A. 5
3·547	Topaz . .	M.A. 1-338
3·55	Aegirine (vanadiferous)	T.A. 4
—	Thortveitite .	M.A. 1-172
—	Olivine (hyalosideritic)	T.A. 5
3·552	Rhodochrosite .	M.A. 2-143
3·557	Yttrofluorite .	T.A. 2
3·558	Aegirine . .	T.A. 4
3·56	Grossular . .	M.A. 2-119
—	Olivine (hyalosideritic)	M.A. 1-109
3·561	Grünerite (calc.)	M.A. 3-153
3·566	Thortveitite .	T.A. 5
3·568	Topaz . .	T.A. 5
3·57	Thortveitite .	M.A. 1-340
3·570	Rhodochrosite .	M.A. 3-124
3·571	Thortveitite .	T.A. 2
3·578	Chapmanite .	M.A. 2-336
3·58	Grossular . .	M.A. 2-357
—	Pseudomalachite	M.A. 2-266
3·584	Triplite . .	M.A. 1-213
3·59	Kyanite . .	M.A. 2-265
—	,, . .	M.A. 3-51
—	Topaz . .	M.A. 3-27
3·593	Kyanite . .	M.A. 2-224
3·596	Hessonite .	M.A. 3-119
3·60	Allanite . .	M.A. 3-9
—	Grossular . .	M.A. 1-9
3·60	Sobralite . .	M.A. 1-253
3·608	Ellsworthite .	M.A. 2-248
3·61	Yttrocerite .	M.A. 2-263
3·611	Grossular . .	T.A. 4
3·620	Chrysoberyl (alexandrite)	T.A. 2
3·63	Chalybite . .	T.A. 4
3·633	,, . .	T.A. 5
—	Hessonite . .	T.A. 4
3·637	Chrysoberyl .	T.A. 4
3·64	Aurichalcite .	M.A. 2-111
—	Jarosite . .	M.A. 2-113
—	Pyrope . .	T.A. 1
—	Sarcopside .	M.A. 1-175
3·645	Allanite . .	T.A. 4
3·65	Grossular . .	T.A. 5
—	Hinsdalite .	T.A. 2
3·658	Allanite . .	M.A. 2-236
3·660	Andradite. .	T.A. 4
3·666	Metabrucite (art.)	T.A. 4
3·668	Rhodochrosite .	M.A. 3-124
3·67	Alstonite . .	T.A. 1
—	Meta-torbernite (art.)	M.M. 19-45
—	Tyuyamunite .	M.A. 2-404
3·68	Meta-torbernite.	M.M. 19-44
—	Torbernite .	M.A. 2 183
3·681	Pyrope . .	M.A. 2-212
3·682	Spinel . .	T.A. 5
3·683	Alkali-spinel .	M.A. 2-185
3·687	Chrysoberyl .	T.A. 4
3·69	Andradite .	M.M. 17-52
3·691	Rhodochrosite .	M.A. 3-59
3·693	Poechite . .	M.A. 1-423
3·695	Svabite . .	M.A. 3-364
3·698	Rhodochrosite .	M.A. 3-124
3·702	Chrysoberyl .	T.A. 4
3·707	Alstonite . .	T.A. 1
—	Chalybite . .	T.A. 5
3·71	Barytocalcite .	T.A. 1
—	Rhodochrosite .	M.A. 2-46
3·715	Pyrope . .	T.A. 4
3·72	Picrotephroite .	T.A. 5
—	Pyrope . .	T.A. 1
3·721	Poechite . .	M.A. 1-423
3·73	Chrysoberyl .	T.A. 4
3·732	Aenigmatite .	M.A. 2-264
3·74	Sklodowskite .	M.A. 2-384
3·743	Rhodochrosite .	T.A. 5
3·75	Betafite . .	T.A. 3
—	Chalybite . .	M.A. 3-358
—	Dussertite. .	M.A. 2-419
—	Pyrope . .	T.A. 1
—	Rhodolite . .	T.A. 4
3·750	Andradite (calc.)	T.A. 4
3·753	Staurolite . .	T.A. 4
3·757	Heterobrochantite	M.A. 3-270
3·758	Aenigmatite .	M.A. 2-264
—	Ellsworthite .	M.A. 2-248
3·759	Staurolite. . .	T.A. 4

3·76	Tilasite	M.A. 2-412
3·769	Atacamite	T.A. 2
3·77	Almandine	M.A. 2-119
—	Tilasite	M.M. 16-95
3·771	Allanite	T.A. 4
3·776	Staurolite	M.A. 2-224
3·778	,,	T.A. 4
3·78	Uranotile	M.A. 1-244
3·780	Atacamite	T.A. 2
3·781	Andradite	T.A. 4
3·782	Almandine-pyrope	T.A. 6
3·79	Tilasite	M.A. 2-412
—	Triplite	T.A. 4
3·793	Chalybite	T.A. 5
3·80	Almandine-pyrope	T.A. 4
—	Pyroxmangite	T.A. 4
3·801	Demantoid	T.A. 4
3·81	Högbomite	M.A. 1-252
—	Uvarovite	T.A. 1
3·813	Chalybite	T.A. 5
3·82	Almandine-pyrope	T.A. 4
—	Calcio-ancylite	M.A. 2-263
—	,,	M.A. 2-407
3·824	Allanite	M.A. 3-268
3·83	Almandine-pyrope	T.A. 6
—	Ferro-anthophyllite	M.A. 1-253
3·837	Rhodolite	T.A. 4
3·84	Chalybite	M.A. 2-46
—	Torbernite	M.A. 2-183
—	Celestine	M.A. 2-137
3·841	Spinel	T.A. 5
3·85	Andradite	M.A. 2-439
3·86	Garnet	M.A. 1-163
—	Zinco-rhodochrosite	T.A. 3
3·87	Allanite	T.A. 4
—	Limonite	M.M. 18-343
3·875	Triplite	T.A. 1
3·88	Almandine	M.A. 2-119
—	Brochantite	M.A. 2-320
—	Chalybite	M.A. 1-15
—	Celestine	M.A. 2-137
3·882	Almandine-pyrope	T.A. 6
3·90	Allanite (Mg-orthite)	M.A. 3-274
3·908	Garnet (melanite)	M.A. 2-212
3·91	Fayalite (art.)	M.A. 3-167
—	Hodgkinsonite	T.A. 4
3·917	Almandine	T.A. 6
3·92	Celestine	T.A. 5
3·924	Ampangabeite	T.A. 4
—	Spinel	T.A. 4
3·927	Chalybite	M.A. 3-59
3·93	Ferropicotite	T.A. 5
3·935	Blende	T.A. 3
3·94	Almandine	T.A. 6
—	Celestine	M.A. 2-137
—	Chalybite	M.A. 3-46
3·95	Almandine-pyrope	T.A. 4
—	Anatase	M.A. 2-358
3·95	Ilvaite	T.A. 3
—	Torbernite	M.A. 2-183
—	Tyuyamunite	M.A. 2-404
3·951	Chalybite	T.A. 5
3·96	,, (calc.)	T.A. 5
3·960	Almandine	T.A. 4
3·965	,,	T.A. 6
3·968	Brookite	T.A. 4
—	Celestine	T.A. 4
3·97	Almandine	T.A. 6
—	Sapphire	M.A. 2-5
—	Paredrite	M.A. 1-256
—	Ampangabeite	T.A. 3
3·977	Corundum (art.)	T.A. 1
3·98	Blende	T.A. 3
—	Olivine (hortonolite)	M.M. 16-378
3·984	Almandine	T.A. 6
3·988	Corundum (art.)	T.A. 1
3·99	Almandine	T.A. 6
3·991	Margarosanite	M.A. 1-18
4·0	Gadolinite	T.A. 5
4·00	Allanite	M.A. 3-274
—	Almandine	T.A. 6
—	Corundum (art.)	M.A. 3-191
4·000	Ilvaite	M.A. 3-307
4·01	Corundum (art.)	T.A. 1
—	Hercynite	M.A. 3-353
—	Kalkowskyn	M.A. 2-419
4·02	Almandine	T.A. 6
—	Gadolinite	T.A. 5
4·025	Almandine	T.A. 4
4·027	Barylite	M.A. 2-411
4·03	Corundum (art.)	M.A. 3-191
4·030	Blende	T.A. 3
4·032	Pisekite	M.A. 2-336
4·033	Blende	M.A. 1-163
4·04	Chalmersite	M.A. 1-173
4·040	Almandine	T.A. 4
4·044	Tephroite	T.A. 4
4·048	Zircon	M.A. 3-55
4·058	Spessartine	T.A. 4
4·059	,,	T.A. 1
4·063	,,	T.A. 4
4·07	Blomstrandite	T.A. 1
4·076	Grossular	T.A. 6
4·079	Blende	T.A. 3
4·08	Paredrite	M.A. 1-256
4·087	Wurtzite (art.)	T.A. 3
4·09	Blende	M.A. 2-110
—	Lepidocrocite	T.A. 5
—	Rosasite	M.A. 2-240
—	Spessartine	M.A. 1-253
4·090	Blende	T.A. 3
4·093	Almandine	T.A. 4
4·1	Bolivianite	M.A. 3-112
—	Zircon (oyamalite)	M.A. 3-10
4·10	Cornetite	M.M. 19-229
4·102	Zircon (cyrtolite)	M.A. 2-236
4·104	Cuprozincite	M.A. 1-203

4·115	Mangan-almandine	M.A. 1–253
4·118	Spessartine	T.A. 4
4·12	Ceylonite	M.M. 19–106
—	Chalcopyrite	M.A. 2–110
4·120	Ampangabeite	T.A. 4
4·123	Rutile	T.A. 4
—	Gadolinite	T.A. 4
4·13	Almandine	M.A. 3–23
4·135	,,	T.A. 4
4·137	Paraurichalcite	M.A. 1–203
4·15	Allanite	M.A. 2–185
4·158	Spessartine	T.A. 4
4·163	Almandine	T.A. 4
4·169	Spessartine	T.A. 4
4·17	Betafite	T.A. 3
—	Blomstrandite	T.A. 2
—	,,	T.A. 1
—	Almandine-spessartine	T.A. 4
4·173	Sarkinite	M.A. 3–360
4.178	,,	M.A. 3–360
4·18	Goethite	M.M. 18–347
—	Paraurichalcite	T.A. 5
4·180	Spessartine (calc.)	T.A. 4
4·19	Barthite	T.A. 4
—	Smithsonite	M.A. 2–111
4·193	Goethite	T.A. 4
4·2	Samarskite	T.A. 2
4·20	Dixenite	M.A. 1–149
—	Allanite	M.A. 1–251
—	Psilomelane	M.A. 1–379
4·201	Paraurichalcite	M.A. 1–203
4·208	Gadolinite	M.A. 3–152
4·21	Vonsenite	T.A. 5
4·22	Powellite	M.A. 2–113
4·223	Gadolinite	T.A. 4
4·227	Staszicite	M.A. 2–52
4·23	Almandine	M.A. 2–265
—	Armangite	M.A. 1–124
—	Rutile (calc.)	M.A. 2–189
4·230	Spessartine	T.A. 4
4·234	Grossular	T.A. 5
4·239	Rutile	T.A. 4
4·24	Fayalite	T.A. 2
4·25	Mangan-fayalite	T.A. 4
4·250	Almandine (calc.)	T.A. 4
4·254	Grossular	T.A. 5
4·255	Spessartine	T.A. 4
4·26	Dysanalyte	T.A. 4
4·272	Rutile	M.A. 2–568
4·273	Spessartine	T.A. 4
4·276	Zircon	M.A. 3–356
4·277	Spessartine	T.A. 4
4·28	Fayalite	T.A. 4
—	Goethite	M.A. 1–143
—	Gadolinite	T.A. 5
4·285	Swedenborgite	M.A. 2–339
4·29	Sr-Baryte	M.A. 1–356
—	Manganite	M.A. 1–124
—	Smithsonite	M.A. 2–111
—.	Witherite	M.A. 2–111
4·29	Ampangabeite	T.A. 3
4·298	Gadolinite	M.A. 2–46
4·3	,,	T.A. 5
—	Schafarzikite	M.A. 3–99
—	Zircon	M.A. 3–9
—	Zirkelite	M.M. 16–310
4·30	Psilomelane	M.A. 1–379
—	Gadolinite	T.A. 5
4·31	Hulsite	T.A. 1
4·32	Gadolinite	T.A. 5
—	Mangan-fayalite	M.A. 1–253
—	Zirkelite	16–313
4·320	Parisite	T.A. 2
4·33	Almandine	T.A. 6
—	Higginsite	M.A. 1–122
—	Hydrohaematite	M.A. 2–111
4·35	,,	M.M. 18–343
—	Spessartine	M.A. 3–208
—	Tyuyamunite	M.A. 2–404
4·36	Gadolinite	T.A. 4
4·37	Gahnite	T.A. 5
—	Smithsonite	M.A. 2–111
4·39	Margarosanite	M.A. 1–19
—	Smithsonite	M.A. 2–111
4·398	,,	M.M. 21–54
4·4	Zircon (hagatalite)	M.A. 3–10
—	,,	M.A. 3–9
4·40	Smithsonite (herrerite)	M.A. 2–111
—	Zirkelite	M.M. 16–313
4.410	Smithsonite	M.A. 2–567
4·415	Chromohercynite	M.A. 1–123
4·417	Hatchettolite	M.A. 2–236
4·43	Villamaninite	M.A. 1–24
4·433	,,	M.M. 19–17
4·44	Ilmenite	T.A. 2
—	Mendelyeevite	M.A. 2–147
4·45	Gadolinite	T.A. 5
4·454	Thalenite	M.A. 2–25
4·46	Germanite	M.A. 2–12
4·47	Zirkelite	M.A. 16–313
4·478	Gahnite	T.A. 4
4·481	Goethite	T.A. 4
4·49	Ampangabeite	M.A. 3–114
—	Enargite	M.A. 3–101
4·5	Katoptrite	M.A. 1–19
—	Brannerite	M.A. 1–22
4·50	Palmierite	M.A. 1–216
4·509	Hatchettolite	M.A. 2–236
4·51	Mendelyeevite	M.A. 2–147
4·52	Villamaninite	M.A. 1–24
4·523	,,	M.M. 19–17
4·55	Enargite	M.A. 2–188
—	Ilmenite	T.A. 4
—	Xenotime?	M.A. 2–254
4·56	Gahnite (dyslusite)	T.A. 1
—	Pyrrhotine	T.A. 3
4·576	Tennantite	T.A. 1
4·583	Zircon	T.A. 4
4·59	Germanite	T.A. 6

4·594	Euxenite	T.A. 4
4·597	Tetrahedrite	T.A. 1
4·6	Gadolinite	T.A. 5
—	Hetaerolite	T.A. 4
—	Zirkelite	M.M. 16–310
4·60	Pseudobrookite	M.A. 3–251
4·602	Gahnite	T.A. 4
4·609	Marcasite	T.A. 2
4·61	Tennantite	M.M. 15–387
—	,,	M.A. 1–150
4·619	Zircon	M.A. 3–356
4·62	Baryte (plumbiferous)	M.M. 19–74
—	Bravoite	M.A. 3–154
—	Molybdenite	T.A. 4
4·627	Soddite	M.A. 1–377
4·63	Zircon	M.M. 21–176
4·637	,,	M.A. 3–356
4·638	Pentlandite	T.A. 4
4·64	Tetrahedrite	M.A. 2–432
4·644	Zircon	M.A. 2–137
—	Ampangabeite	T.A. 4
4·65	Covellite (art.)	M.A. 2–20
4·650	Euxenite	T.A. 4
4·651	Stibnite	M.A. 2 562
—	Tetrahedrite	T.A. 1
4·652	Covellite	T.A. 4
—	Zircon	M.A. 2–137
—	,,	M.A. 3–356
4·654	Stibnite	M.A. 3–208
4·67	Troilite	M.A. 2–43
4·671	Zircon	M.A. 3–356
4·676	Covellite	T.A. 4
4·679	Zircon	M.A. 3–356
4·68	Covellite	M.A. 2–20
—	Tetrahedrite	T.A. 1
4·680	Zircon	M.A. 3–356
4·682	,,	M.A. 2–288
—	,,	M.A. 3–356
4·683	Covellite	T.A. 4
4·686	Zircon (heated)	T.A. 4
4·69	Ilmenite	T.A. 4
—	Zircon	M.A. 2–288
—	,,	M.A. 3–296
4·692	Tennantite (julianite)	T.A. 1
—	Zircon	M.A. 3–356
4·7	Hydrohaematite	T.A. 5
4·700	Tennantite (miedziankite)	M.A. 3–233
4·702	Zircon	M.A. 3–356
4·707	,,	M.A. 3–356
4·710	Euxenite	T.A. 4
—	Ilmenite	T.A. 4
4·711	Euxenite	T.A. 4
4·716	Cobalt-nickel-pyrite	T.A. 4
4·72	Zirkelite	M.M. 16–310
4·720	Zircon	M.A. 3–356
4·722	,,	M.A. 3–356
—	Euxenite	T.A. 4
4·73	Loparite	M.A. 3–275
4·736	Tetrahedrite	T.A. 1
4·738	,,	T.A. 1
4·74	Boleite (cumengeite)	T.A. 5
4·740	Tetrahedrite	T.A. 1
4·741	Zirkelite	M.M. 16–313
4·746	Tennantite	T.A. 1
4·748	Pyrolusite	M.A. 1–413
—	Zircon	M.A. 3–55
4·75	Boleite (cumengeite)	T.A. 5
—	Mendelyeevite	T.A. 6
4·751	Ilmenite	M.A. 2–224
4·754	Euxenite	T.A. 4
4·76	Mendelyeevite	M.A. 2–147
4·766	,,	T.A. 6
4·769	Tetrahedrite	T.A. 1
4·77	Cumengeite	M.A. 1–76
—	$FeTiO_3$ (calc.)	M.A. 2–189
—	Loparite	M.A. 3–236
4·778	Hausmannite	M.A. 1–47
4·779	Tetrahedrite	T.A. 1
4·78	Pageite	T.A. 1
—	Tetrahedrite	M.A. 2–110
4·780	,,	T.A. 1
4·794	,,	T.A. 1
4·8	Dewindtite	M.A. 1–377
—	Lubeckite	M.A. 2–52
4·802	Boleite	M.A. 1–76
4·81	Euxenite	M.A. 2–407
4·82	Linnaeite	M.A. 2–342
4·820	Greenockite (art.)	T.A. 3
4·836	Hausmannite	M.A. 1–47
4·85	Hetaerolite	T.A. 1
—	Linnaeite	M.A. 2–183
4·86	Ilmenite	T.A. 1
4·862	Euxenite	T.A. 1
4·87	Tetrahedrite	T.A. 1
4·879	Marcasite	T.A. 2
4·88	Blomstrandine	M.A. 2–408
—	Boleite (cumengeite)	T.A. 5
4·885	Pyrolusite	T.A. 5
4·887	Marcasite	T.A. 3
4·888	Tetrahedrite	M.A. 1–337
4·89	Mackensite	M.A. 1–255
4·895	Euxenite	T.A. 2
4·897	Tetrahedrite	M.A. 1–337
4·91	Strüverite	T.A. 3
4·94	Törnebohmite	M.A. 1–251
4·948	Bastnäsite	T.A. 3
4·95	$CaNb_2O_6$ (calc.)	M.M. 18–119
4·964	Weslienite	T.A. 6
4·965	Cobalt-pyrite	M.A. 2–339
4·967	Becquerelite	T.A. 6
—	Magnetite	T.A. 4
—	Weslienite	M.A. 2–253
4·970	Pyrite	T.A. 2
4·971	Weslienite	T.A. 6
4·972	Crednerite	M.M. 20–87
4·977	Boleite	M.A. 1–76
4·98	Fergusonite	M.A. 2–283
4·99	Euxenite	M.A. 1–73

5·0	Samarskite	T.A. 2
—	Zirkelite	M.M. 16-313
5·00	Blomstrandine	T.A. 1
5·027	Pyrite	T.A. 3
5·03	Crednerite	M.M. 20-88
—	Stasite	M.A. 1-377
5·036	Strüverite	T.A. 4
5·037	Bornite	M.A. 1-341
5·041	Toddite	M.A. 3-271
5·044	Romeite	T.A. 4
5·061	Bornite	T.A. 4
5·064	,,	T.A. 4
5·074	Romeite	T.A. 4
5·079	Bornite	T.A. 4
—	Tetrahedrite	T.A. 1
5·08	Gummite	M.A. 1-415
5·086	Bornite	T.A. 4
5·09	Franklinite	T.A. 1
5·1	Zirkelite	M.M. 16-313
5·103	Bornite	M.A. 1-341
5·11	Monazite	T.A. 3
5·147	Columbite	T.A. 6
5·155	Boleite	M.A. 1-76
5·162	Monazite	M.A. 1-333
5·165	Trevorite	M.A. 2-249
5·169	Pyrite	T.A. 2
5·17	Monazite	T.A. 4
—	,,	M.A. 2 36
5·173	Haematite	T.A. 4
5·18	Ilmenorutile	M.A. 2-405
—	$MnNb_2O_6$ (calc.)	M.M. 18 119
5·2	Monazite	M.A. 1-173
—	Zirkelite	M.M. 16-313
5·20	Mossite (calc.)	M.M. 18-119
—	Columbite	M.A. 2-473
5·201	,,	M.A. 2-192
5·21	Bayldonite	T.A. 5
—	Keeleyite	M.A. 2-11
5·22	Zirkelite	M.M. 16-310
5·23	Linarite	T.A. 2
5·24	Monazite	T.A. 4
—	Samiresite	T.A. 3
5·25	Ambatoarinite	M.A. 1-148
—	Monazite	T.A. 4
—	Strüverite	T.A. 2
5·261	Haematite	T.A. 4
5·262	,,	T.A. 2
5·273	Columbite	T.A. 4
—	Monazite	T.A. 4
5·28	Columbite	T.A. 5
—	,,	M.A. 1-173
5·29	Cesarolite	M.A. 1-201
5·3	Columbite	T.A. 5
5·30	Fergusonite	M.A. 3-10
—	,,	M.A. 3-268
—	Strüverite	M.M. 16-225
—	Vrbaite	T.A. 3
5·31	Monazite	T.A. 4
—	Samarskite	M.A. 2-406
5·35	Bismutoplagionite	M.A. 1-75
5·36	Eichbergite	T.A. 2
—	Miargyrite (art.)	T.A. 3
5·364	Manganosite	T.A. 1
5·37	Columbite	T.A. 5
5·377	Pyrobelonite	M.A. 1-124
5·4	Pufahlite	M.A. 2-520
5·40	Samarskite	M.A. 2-408
5·41	Columbite	T.A. 5
—	Schneebergite	T.A. 4
5·42	Columbite	T.A. 5
5·421	,,	T.A. 5
5·43	Samarskite	M.A. 2-406
—	Brannerite	M.A. 1-22
5·431	Columbite	T.A. 6
5·44	,,	T.A. 5
—	Parabayldonite	T.A. 5
—	Seligmannite	M.M. 15-386
5·447	Aramayoite	M.A. 3 269
5·453	Rathite?	M.M. 18 362
5·47	Plagionite (art.)	T.A. 3
5·48	Columbite	T.A. 5
—	Seligmannite	M.M. 15-386
5·49	Berthonite	M.A. 2-149
5·496	Columbite	T.A. 5
5·5	Bornite	M.A. 1-250
—	Cuproplumbite	T.A. 5
5·50	Bayldonite	T.A. 5
—	Samarskite	T.A. 5
—	,,	M.A. 2-406
5·502	Cuproplumbite	T.A. 5
5·504	Parabayldonite	T.A. 5
5·51	Chalcosine	T.A. 4
—	Proustite (art.)	T.A. 3
5·512	Parabayldonite	T.A. 5
5·517	Magnetoplumbite	M.A. 3-5
5·52	Columbite	T.A. 3
—	,,	T.A. 5
—	,,	M.A. 1-173
5·54	Plagionite	T.A. 3
5·563	Columbite	T.A. 6
5·576	Ganomalite	T.A. 5
5·58	Fergusonite	T.A. 2
5·59	Columbite	M.A. 2-36
5·590	Chalcosine	T.A. 4
5·594	,,	T.A. 4
5·60	Proustite	T.A. 4
5·602	Aramayoite	M.M. 21-161
5·613	Columbite	T.A. 6
5·62	Jamesonite	T.A. 3
5·63	Microlite	M.A. 1-73
5·636	Arsenic	M.M. 20-301
5·685	Schoepite	M.A. 2-384
5·694	Chalcosine	T.A. 4
5·70	Arseno-bismite	M.A. 1-255
—	Samarskite	M.A. 2-406
—	Columbite	M.A. 3-284
5·703	Chalcosine	T.A. 4
5·73	Fluocerite	M.A. 1-258
5·774	Chalcosine	T.A. 4
5·78	Arsenic	M.A. 3-145

5·78	Fergusonite	M.A. 2-405
5·781	Chalcosine	T.A. 4
5·783	,,	T.A. 4
5·785	,, (art.)	M.A. 2-19
5·790	Pyrargyrite (art.)	T.A. 3
5·80	Allemontite	M.A. 1-356
5·81	Bournonite	T.A. 4
5·829	,,	M.A. 1-423
5·84	Semseyite	M.M. 18-358
5·87	Eschwegeite	M.A. 3-113
5·88	Mispickel	M.A. 1-423
5·9	Scheelite	M.A. 3-140
5·90	Mottramite	M.A. 1-150
5·92	Allemontite	T.A. 5
5·93	Mottramite	M.A. 1-150
5·943	Schultenite	M.M. 21-155
5·96	Gersdorffite	T.A. 5
5·962	Kasolite	M.A. 1-249
6·00	Descloizite	M.A. 1-144
6·02	Hydrocerussite	M.A. 2-111
6·026	Ultrabasite	M.A. 1-149
6·04	Samarskite	M.A. 2-406
6·046	Fourmarierite	M.A. 2-343
6·05	Allemontite	T.A. 5
—	Semseyite	M.A. 3-8
6·07	Cosalite	M.A. 1-259
—	Wolframite	M.A. 2-113
6·08	Phosgenite	M.A. 2-475
6·1	Mispickel	M.A. 1-336
6·12	Phosgenite	M.A. 3-29
6·127	Stromeyerite	M.A. 2-470
6·14	Cocinerite	M.A. 1-18
—	Mispickel	M.A. 1-337
6·15	Gersdorffite	M.A. 1-330
6·19	Duftite	M.A. 1-150
—	Cuprodescloizite	M.A. 1-150
6·2	Ishikawaite	M.A. 2-9
6·23	Alaskaite	M.A. 3-272
—	Parsonsite	M.A. 2-50
—	Columbite	M.A. 3-284
6·24	Phosgenite	M.A. 2-111
6·26	Stromeyerite	M.A. 2-110
6·260	,,	M.A. 2-519
6·274	Boulangerite (mullanite)	M.A. 1-151
6·303	Epiboulangerite	M.A. 1-150
6·34	Allemontite	M.A. 1-356
6·350	Anglesite	T.A. 4
6·4	Ishikawaite	M.A. 2-9
6·407	Boulangerite (mullanite)	M.A. 1-151
6·412	Diaboleite	M.M. 20-79
6·43	Meneghinite	T.A. 1
6·444	Columbite	T.A. 5
6·451	Jordanite (reniforite)	M.A. 3-114
6·46	Cerussite	M.A. 2-111
—	Vanadinite	M.A. 1-295
6·5	Tantalite	T.A. 5
6·50	Manganotantalite	M.A. 1-80
6·519	Skutterudite	M.A. 3-305
6·527	Naumannite	M.A. 1-144
6·53	Barysilite	M.A. 1-48
6·535	Kobellite	T.A. 4
6·54	Cannizzarite	M.A. 3-10
—	Cerussite	M.A. 2-111
6·55	Bismuthinite	M.A. 2-562
—	Cosalite	M.A. 1-293
6·70	Ullmannite	T.A. 1
6·706	Barysilite	M.A. 1-48
6·725	Columbite	T.A. 5
6·73	Bismuthinite	M.A. 1-77
6·734	Rammelsbergite	M.A. 3-305
6·76	Cosalite	M.A. 1-293
6·763	Chloroxiphite	M.M. 20-76
6·781	Cassiterite	M.M. 16-119
6·786	Hydrocerussite	M.M. 20 85
6·79	Skutterudite	M.A. 1-356
6·80	Cosalite	M.A. 1-293
—	Hydrocerussite	M.M. 20 84
6·842	Quenselite	M.A. 3-110
6·845	Columbite	T.A. 5
6·913	Cassiterite	M.A. 1-144
6·93	Penroseite	M.A. 3-112
—	Wolframite	M.A. 2-113
6·94	Cosalite	M.A. 1-259
6·954	Tantalite	T.A. 5
6·96	Gladite	M.A. 2-340
6·98	Mimetite	M.A. 1-150
7·0	Rammelsbergite	M.A. 1-410
7·01	Lindströmite	M.A. 2-340
7·019	Tantalite	T.A. 5
7·02	Rammelsbergite	T.A. 5
7·04	Galenobismutite	M.A. 2-339
7·05	Pyromorphite	T.A. 4
7·062	Tantalite	M.A. 1 73
7·07	Matildite	T.A. 5
—	Pyromorphite	T.A. 4
—	Wolframite	M.A. 2-113
7·08	Finnemanite	M.A. 2-147
—	Pyromorphite	T.A. 4
7·09	Lillianite	M.A. 1-259
—	Pyromorphite	T.A. 4
—	Wolframite (hübnerite)	T.A. 4
7·10	Pyromorphite	T.A. 4
—	Wolframite	M.A. 3-305
7·11	Pyromorphite	T.A. 4
7·12	,,	T.A. 4
—	Wittite	M.A. 2-340
—	Galenobismutite	M.A. 2-339
7·124	Pyromorphite	M.A. 3-310
7·126	Pitchblende	M.A. 2-182
7·13	Cosalite	M.A. 3-8
7·14	Lillianite	T.A. 1
7·15	Mimetite	M.A. 1-126
—	Se-chiviatite	M.A. 2-341
7·162	Wolframite	T.A. 4
7·163	Warthaite	M.A. 3-7
7·180	Tantalite	T.A. 5
7·186	Mimetite	M.A. 3-310

7·190	Tapiolite	T.A. **5**
7·192	Curite	M.A. **1**–249
7·2	Wolframite	M.A. **3**–140
7·22	Löllingite	T.A. **5**
7·23	Metacinnabarite (leviglianite)	M.A. **3**–206
—	Wolframite	M.A. **3**–155
7·235	Argentite	T.A. **6**
7·240	Mendipite	M.M. **20**–74
7·265	Finnemanite	M.A. **2**–147
7·272	Wolframite	T.A. **4**
7·275	Löllingite	T.A. **5**
7·29	Goongarrite	M.A. **2**–336
7·30	Galena	M.A. **2**–110
—	Tantalite	T.A. **5**
7·301	,,	M.A. **1**–73
7·33	Löllingite	T.A. **5**
7·36	Tapiolite	M.M. **18**–115
7·39	Galena	M.A. **2**–110
—	Lorettoite	M.A. **1**–120
—	Schwartzembergite	T.A. **2**
7·4	Tapiolite	T.A. **5**
7·40	Argentite	T.A. **4**
7·44	Tapiolite	M.M. **18**–114
7·45	,,	M.M. **18**–115
7·46	,,	M.M. **18**–114
7·468	Tantalite	T.A. **5**
7·49	Wolframite	M.A. **3**–155
7·50	Galena	M.A. **2**–110
7·510	Empressite	T.A. **4**
7·52	Tapiolite	M.M. **18**–114
7·53	Petzite	M.A. **3**–305
7·55	Galena	M.A. **2**–110
7·6	Oruetite	M.A. **1**–201
7·65	Lorettoite	M.A. **1**–120
—	$CaTa_2O_6$(calc.)	M.M. **18**–119
7·688	Joseite	M.A. **1**–420
7·69	Tapiolite	M.M. **18**–111
7·73	Maucherite	T.A. **4**
7·746	Awaruite	T.A. **2**
7·793	Joseite	M.A. 1–420
7·794	Tantalite	T.A. **5**
7·80	Maucherite	T.A. **4**
7·81	Maucherite	T.A. **4**
7·83	,,	T.A. **4**
7·839	Tapiolite	M.M. **18**–117
7·84	,,	M.M. **18**–116
7·875	,,	M.M. **18**–117
7·878	Tantalite	T.A. **5**
7·88	Ixiolite (calc.)	M.M. **18**–119
7·90	Tapiolite (calc.)	M.M. **18**–119
7·901	Maucherite	T.A. **4**
7·907	Tapiolite	M.M. **18**–117
7·91	,,	M.M. **18**–116
7·952	Chubutite	M.A. **1**–121
7·975	Tantalite	M.A. **2**–192
—	Kleinite	T.A. **1**
7·98	Platynite	T.A. **1**
7·987	Kleinite	T.A. **1**
8·00	Hessite	M.A. **3**–264
8·20	Tantalite	M.A. **2**–473
8·28	Trigonite	M.A. **1**–149
8·33	Silver (cupriferous)	M.A. **2**–110
8·61	Massicot	T.A. **4**
8·62	Copper	M.A. **2**–110
8·723	Terlinguaite	T.A. **1**
8·728	,,	T.A. **1**
8·735	Petzite	M.A. **3**–264
8·80	Copper	M.A. **2**–110
9·082	Uraninite	M.A. **2**–409
9·182	,,	M.A. **3**–106
9·33	Thorianite	T.A. **4**
9·660	Uraninite	M.A. **3**–106
9·787	,,	M.A. **3**–106
9·83	Silver	M.A. **2**–110
10·58	Sperrylite	M.M. **21**–95
10·73	,,	M.A. **2**–138
11·2	Tantalum	T.A. **1**
11·273	Lead	M.A. **1**–103
13·33	Pd-amalgam	M.A. **3**–4
14·68	Gold (electrum)	M.A. **2**–110
15·82	Pd-amalgam	M.A. **3**–4
15·96	Gold (electrum)	M.A. **2**–110
16·4	Platinum	M.A. **2**–441
18·35	,,	M.A. **2**–442
19·0	,,	M.A. **2**–441

Alphabetical List of Minerals giving the minimum and maximum recorded values of specific gravity.

Acmite-augite, 3·26–3·42
Actinolite, 2·913–3·079
Aegirine, 3·3–3·558
Aenigmatite, 3·732–3·758
Afwillite, 2·619 2·630
Ajkaite, 1·541
Åkermanite, 2·944–2·980
Akrochordite, 3·194
Alaskaite, 6·23
Albite, 2·603–2·688
Allanite, 2·50–4·20
Allemontite, 5·80–6·34
Allophane, 1·88–1·94
Almandine, 3·77–4·33
Almandine-pyrope, 3·80–3·95
Alstonite, 3·67–3·707
Alunite, 2·63–2·726
Alunogen, 1·718–1·735
Ambatoarinite, 5·25
Amblygonite, 2·989–3·101
Amesite, 2·77
Ampangabeite, 3·348–4·644
Analcime, 2·2–2·285
Anatase, 3·95
Anauxite, 2·524
Ancylite, calcio-, 3·82
Andalusite, 3·118–3·29
Andesine, 2·663–2·675
Andradite, 3·50–3·85
Anemousite, 2·684
Anglesite, 6·350
Anhydrite, 2·981
Ankerite, 2·99–3·19
Annabergite, 2·907
Anorthite, 2·703–2·763
Anorthoclase, 2·584–2·63
Anthophyllite, 2·95–3·138
— ferro-, 3·24–3·83
Anthraxolite, 1·845
Antigorite, 2·613
Apatite, 3·151–3·270
— chlor-, 3·14–3·20
— fluor-, 3·18–3·206
— mangan-, 3·257
— sulphate-, 3·196–3·207
Aphrosiderite, 2·959
Aphthitalite, 2·7
Apophyllite, 2·323–2·379
Aragonite, 2·861–3·15
Arakawaite, 3·09
Aramayoite, 5·447–5·602
Arduinite, 2·26
Argentite, 7·235–7·40
Armangite, 4·23
Arsenic, 5·636–5·78
Arseno-bismite, 5·70
Asbestos, amphibole-, 2·97
Asbolane, 2·985
Ascharite, 2·69
Atacamite, 3·769–3·780
Augite, 3·242–3·44
— titan-, 3·29–3·39
Aurichalcite, 3·274–3·64
Autunite, 3·198
Avogadrite, 2·498–2·617
Awaruite, 7·746
Axinite, 3·22–3·314

Bababudanite, 3·18
Babingtonite, 3·351–3·398
Bardolite, 2·470
Barkevikite, 3·298–3·518
Barthite, 4·19
Barylite, 4·027
Barysilite, 6·53–6·706
Baryte (Sr-), 4·29
Baryte (Pb-), 4·62
Barytocalcite, 3·71
Bassetite, 3·10
Bastnäsite, 4·948
Bauxite, 2·4–2·5
Bavalite, 3·20
Bayldonite, 5·21–5·50
Bazzite, 2·80
Becquerelite, 4·967
Bementite, 3·106
Bentonite, 2·44–2·78
Beraunite, 2·850–2·99
Berthonite, 5·49
Bertrandite, 2·59–2·604
Beryl, 2·545–2·910
Betafite, 3·75–4·17
Biotite, 2·692–3·16
Bismuthinite, 6·55–6·73
Bismutoplagionite, 5·35
Blende, 3·935–4·09
Bloedite, 2·32
Blomstrandine, 4·88–5·00
Blomstrandite, 4 7–4·17
Boleite, 4·74–5·155
Bolivarite, 2·05
Bolivianite, 4·1
Boothite, 2·02
Boracite, 2·89–2·91
Bornite, 5·037–5·5
Boulangerite, 6·274–6·407
Bournonite, 5·81–5·829
Brannerite, 4·5–5·43
Bravoite, 4·62
Brochantite, 3·88
Bronzite, 3·208–3·338
Brookite, 3·968
Brucite, 2·38–2·39
Buttgenbachite, 3·33

Calcio-thomsonite, 2·405
Calcite, 2·699–2·82
Camsellite, 2·60
Cancrinite, 2·41–2·47
Cannizzarite, 6·54
Carnegeite, 2·513
Cassiterite, 6·718–6·913
Catapleiite, α-, 2·658
Cebollite, 2·96
Celestine, 3·84–3·968
Centrallasite, 2·51
Cerussite, 6·46–6·54
Cesarolite, 5·29
Ceylonite, 4·12
Chabazite, 2·09–2·168
Chalcedony, 2·55–2·63
Chalcoalumite, 2·29
Chalcopyrite, 4·12
Chalcosine, 5·51–5·785
Chalmersite, 4·04
Chalybite, 3·63–3·96
Chapmanite, 3·578
Chiolite, 2·995–3·005
Chiviatite, 7·15
Chlorite, 2·386–2·396
Chloritoid, 3·45
Chloromelanite, 3·365
Chlorophaeite, 1·81
Chloroxiphite, 6·763
Chondrodite, 3·175
Chromohercynite, 4·415
Chrysoberyl, 3·49–3·73
Chrysocolla, 2·400–2·417
Chrysotile, 2·457–2·57
Chubutite, 7·952
Clinochlore, 2·657–2·787
Clinozoisite, 3·212–3·366
Clintonite, 3·093
Cobalt-nickel-pyrite, 4·716
Cobalt-pyrite, 4·965
Cocinerite, 6·14

Colerainite, 2·51
Collophane, 2·6–2·9
Columbite, 5·147–6·845
Connellite, 3·54
Copiapite, 2·087
Copper, 8·62–8·80
Cordierite, 2·571–2·660
Cornetite, 4·10
Corundophyllite, 2·881
Corundum, 3·97–4·03
— β-, 3·30
Cosalite, 6·07–7·13
Couzeranite, 2·625
Covellite, 4·65–4·683
Crednerite, 4·972–5·03
Creedite, 2·713–2·730
Crestmoreite, 2·22
Cristobalite, 2·32–2·36
Crocidolite, 3·20
Cryolithionite, 2·774
Cryptohalite, 2·004
Cumengeite, 4·74–4·88
Cummingtonite, 3·23
Cuprodescloizite, 6·19
Cuproplumbite, 5·5–5·502
Cuprozincite, 4·104
Curite, 7·192
Curtisite, 1·21
Cuspidine, 2·965–2·989
Custerite, 2·91

Dahllite, 3·00–3·094
Damourite, 2·872
Danburite, 2·93–2·974
Dannemorite, 3·516
Datolite, 2·993–3·001
Davyne, 2·34–2·492
Delvauxite, 1·815–1·999
Demantoid, 3·801
Descloizite, 6·00
Destinezite, 2·105
Dewindtite, 4·8
Diabantite, 2·77–2·79
Diaboleite, 6·412
Diamond, 3·513–3·514
Diaspore, 3·385
Diopside, 3·037–3·544
— -jadeite, 3·270–3·330
— chrome-, 3·337
— fluor-, 3·236
Dioptase, 3·296–3·318
Dixenite, 4·20
Dolomite, 2·829–2·993
Dufrenite, 3·5
Duftite, 6·19
Dumortierite, 3·30–3·36
Dussertite, 3·75
Dysanalyte, 4·26

Eakleite, 2·685–2·705
Eichbergite, 5·36
Ekmannite, 2·671
Ektropite, 2·46
Ellsworthite, 3·608–3·758
Elpidite, titano-, 2·533–2·560
Emerald, 2·648–2·709
Empressite, 7·510
Enargite, 4·49–4·55
Enstatite, 3·254–3·303
Epiboulangerite, 6·303
Epichlorite, 2·52
Epidesmine, 2·152–2·16
Epidote, 3·187–3·507
Epinatrolite, 2·235–2·24
Erythrite, 3·149
Eschwegeite, 5·87
Euclase, 3·05–3·09
Eucolite, 2·97
Eucryptite, 2·667
— pseudo-, 2·365
Eudialyte, 2·84–2·86
Euxenite, 4·594–4·99
Evansite, 1·924–1·929

Fassaite, 3·308
Fayalite, 3·91–4·28
— mangan-, 4·32
Fergusonite, 4·98–5·78
Fermorite, 3·518
Ferrazite, 3·0–3·3
Ferrierite, 2·150
Ferrimolybdite, 2·99
Ferrisymplesite, 2·885
Ferronatrite, 2·6
Ferropicotite, 3·93
Fibroferrite, 1·901–2·09
Fibrolite, 3·10–3·266
Finnemanite, 7·08–7·265
Flagstaffite, 1·092
Flint, 2·61–2·63
Fluoborite, 2·89
Fluocerite, 5·73
Fluorite, 2·97–3·201
Fluosiderite, 3·13
Forsterite, 3·216–3·268
Foshagite, 2·36
Fourmarierite, 6·046
Franklinite, 5·09

Gadolinite, 4·0–4·6
Gahnite, 4·478–4·602
Gajite, 2·619
Galena, 7·30–7·55
Galenobismutite, 7·04–7·12
Ganomalite, 5·576
Gearksutite, 2·710–2·768
Gedrite, 3·240
Gehlenite, 2·969–3·039
Gerhardtite, 3·34–3·46
Germanite, 4·46–4·59
Gersdorffite, 5·96–6·15
Gillespite, 3·33
Gladite, 6·96
Glaucochroite, 2·216
Glauconite, 2·70–2·82
Glinkite, 3·463
Gmelinite, 2·045–2·135
Goethite, 4·18–4·481
Gold (electrum), 14·68–15·96
Goongarrite, 7·29
Graphite, 2·216
Greenockite, 4·820
Griffithite, 2·309
Grodnolite, 2·974
Grossular, 3·226–4·254
Grothine, 3·079–3·090
Grünerite, 3·311–3·561
Guarinite, 3·31
Gummite, 5·08
Gypsum, 2·32
Gyrolite, 2·35–2·40

Haematite, 5·173–5·262
Halite, 2·166
Halloysite, 2·44–2·714
Halotrichite, 1·807–1·899
Hambergite, 2·36
Harmotome, 2·350–2·365
Hastingsite, 3·16–3·426
Hatchettolite, 4·417–4·509
Hausmannite, 4·778–4·836
Hedenbergite, 3·50
Helvine, 3·289
Hercynite, 4·01
Hessite, 8·00
Hessonite, 3·596–3·633
Hetaerolite, 4·6–4·85
Heterobrochantite, 3·757
Heterogenite, 3·128
Heulandite, 2·16–2·249
Hewettite, 2·554
Hexahydrite, 1·757
Hibbenite, 3·213
Higginsite, 4·33
Hinsdalite, 3·65
Hisingerite, 2·50
Hodgkinsonite, 3·91
Hoelite, 1·43
Högbomite, 3·81
Hopeite, 3·03
Hornblende, 3·13–3·518
Hörnesite, 2·57
Hortonolite, 3·98
Hulsite, 4·31
Humboldtilite, 2·92–2·975
Huronite, 2·819
Hyalophane, 2·90
Hydrocerussite, 6·02–6·80

Hydrogiobertite, 2·152
Hydrohaematite, 4·33–4·7
Hydromagnesite, 2·152–2·16
Hydronephelite, 2·40–2·46
Hydrophlogopite, 2·783
Hypersthene, 3·36–3·415

Iddingsite, 2·54–2·80
Idocrase, 3·32–3·47
Ilmenite, 4·44–4·86
Ilmenorutile, 5·18
Ilvaite, 3·95–4·00
Imerinite, 3·02
Inesite, 3·029–3·03
Inyoite, 1·875
Ishikawaite, 6·2–6·4
Ixiolite, 7·88

Jadeite, 3·335
Jamesonite, 5·62
Jarosite, 3·17–3·64
Jefferisite, 2·38
Johannite, 3·307
Johnstrupite, 3·17
Jordanite, 6·451
Joseite, 7·688–7·793
Jurupaite, 2·75
Justite, 2·98–3·24

Kainite, 2·132
Kaliophilite, 2·56–2·61
Kalkowskyn, 4·01
Kämmererite, 2·59–2·67
Kaolin, 2·32–2·59
Kasolite, 5·962
Katangite, 2·4
Katoptrite, 4·5
Keeleyite, 5·21
Kempite, 2·94
Kernite, 1·953
Kieserite, 2·573
Kleinite, 7·975–7·987
Kobellite, 6·535
Kochite, 2·927–2·932
Kornelite, 2·306
Kreuzbergite, 2·139
Kyanite, 3·282–3·593

Labradorite, 2·686–2·718
Lacroixite, 3·126
Lanthanite, 2·69–2·74
Laumontite, 2·272–2·42
Lawsonite, 3·12
Lazulite, 2·958
Lead, 11·273
Leifite, 2·565–2·578
Leonite, 2·201
Lepidocrocite, 4·09
Lepidolite, 2·799–2·881
Lepidomelane, 3·151–3·294
Leuchtenbergite, 2·648–2·735
Leucite, 2·48–2·51
Lillianite, 7·09–7·14
Limnite, 2·8
Limonite, 3·87
Linarite, 5·23
Lindströmite, 7·01
Linnaeite, 4·82–4·85
Lithidionite, 2·56
Lithionite, 2·972
Lithiophilite, 3·39
Lithomarge, 2·54–2·55
Löllingite, 7·22–7·23
Loparite, 4·73–4·77
Lorettoite, 7·39–7·65
Lovchorrite, 3·32
Löweite, 2·374
Lubeckite, 4·8
Lublinite, 2·65
Lucinite, 2·52–2·53
Ludlamite, 3·19

Mackensite, 4·89
Magnalite, 2·34
Magnesite, 2·95–3·12
Magnetite, 4·967
Magnetoplumbite, 5·517
Manganite, 4·29
Manganolangbeinite, 3·02–3·03
Manganophyllite, 2·743–2·954
Manganosite, 5·364
Marcasite, 4·609–4·887
Margarosanite, 3·991–4·39
Marialite, 2·50–2·692
Massicot, 8·61
Matildite, 7·07
Maucherite, 7·73–7·901
Meerschaum, 2·02
Meionite, 2·815
Melanite, 3·908
Melanovanadite, 3·477
Melilite, 2·929–3·24
Mendelyeevite, 4·44–4·766
Mendipite, 7·240
Meneghinite, 6·43
Merrillite, 3·10
Merwinite, 3·150
Mesitite, 3·375
Mesolite, 2·257–2·260
Metabrushite, 3·666
Metacinnabarite, 7·23
Metahewettite, 2·511
Meyerhofferite, 2·120
Miargyrite, 5·36
Microcline, 2·554–2·692
Mimetite, 6·98–7·186
Minguetite, 2·86
Mispickel, 5·88–6·14
Mizzonite, 2·60
Molybdenite, 4·62
Monazite, 5·11–5·31
Monetite, 2·863
Montebrasite, 3·008
Monticellite, 3·04–3·20
Mordenite, 2·125–2·193
Mossite, 5·20
Mottramite, 5·90–5·93
Muscovite, 2·797–2·891
Myeline, 2·714

Natramblygonite, 3·01–3·06
Natrojarosite, 3·11
Natrolite, 2·183–2·248
Naumannite, 6·527
Neotocite, 2·5
Nepheline, 2·528–2·664
Nephrite, 2·938–3·06
Neptunite, mangan-, 3·203
Nocerite, 2·96
Nontronite, 2·29–2·295
Norbergite, 3·13–3·15

Okenite, 2·206–2·332
Oligoclase, 2·612–2·672
— potash-, 2·615–2·625
Olivine, 3·301–3·56
— calc-, 3·190–3·341
— (hortonolite), 3·98
Omphacite, 3·31
Opal, 2·06–2·22
Orientite, 3·05
Orthoclase, 2·536–2·600
Oruetite, 7·6
Oxalite, 2·28

Pachnolite, 2·976
Pageite, 4·78
Palaite, 3·14–3·20
Palladium amalgam, 13·33–15·82
Palmierite, 4·50
Parabayldonite, 5·44–5·512
Paradoxite, 2·425–2·430
Parahopeite, 3·21–3·236
Paraurichalcite, 4·137–4·201
Paravauxite, 2·291–2·30
Paredrite, 3·97–4·08
Pargasite, 3·069–3·181
Parisite, 4·320
Parsettensite, 2·590–2·681
Parsonsite, 6·23

Pascoite, 2·457
Paternoite, 2·11
Pectolite, 2·736–2·857
Pennine, 2·619–2·682
Penroseite, 6·93
Pentlandite, 4·638
Penwithite, 2·20
Petalite, 2·414
Petzite, 7·53–8·735
Phenakite, 2·944–3·041
Phlogopite, 2·737–2·869
Phosgenite, 6·08–6·24
Phosphoferrite, 3·156
Phosphophyllite, 3·081–3·082
Phosphorite, 2·72–2·86
Phosphosiderite, 2·726
Pickeringite, 1·84
Picrotephroite, 3·72
Pinite, 2·780
Pinnoite, 2·292
Pisanite, 1·950
Pisekite, 4·032
Plagionite, 5·47–5·54
Plancheite, 3·37
Platinum, 16·4–19·0
Platynite, 7·98
Plazolite, 3·129
Poechite, 3·693–3·721
Powellite, 4·22
Prehnite, 2·875–2·943
Priceite, 2·43–2·433
Prismatine, 3·345
Prochlorite, 2·60–2·936
Protolithionite, 3·148–3·305
Proustite, 5·51–5·60
Pseudobrookite, 4·60
Pseudomalachite, 3·58
Pseudonepheline, 2·68
Pseudophite, 2·693–2·695
Psilomelane, 4·20–4·30
Ptilolite, 2·10–2·30
Pufahlite, 5·4
Pumpellyite, 3·2
Pyrargyrite, 5·790
Pyrite, 4·970–5·169
Pyrobelonite, 5·377
Pyrolusite, 4·748–4·885
Pyromorphite, 7·05–7·124
Pyrope, 3·510–3·75
Pyrophyllite, 2·659
Pyroxmangite, 3·80
Pyrrhotine, 4·56

Quartz, 2·649–2·697
Quenselite, 6·842
Quisqueite, 1·75

Racewinite, 1·94–1·98
Radiophyllite, 2·45–2·60
Ralstonite, 2·614
Rammelsbergite, 6·734–7·02
Ramsayite, 3·43–3·47
Rancieite, 3·25–3·30
Rathite, 5·453
Reddingite, Fe-, 2·96–3·10
Retinite, 1·03–1·051
Rhodizite, 3·344
Rhodochrome, 2·644
Rhodochrosite, 3·312–3·743
— zinco-, 3·86
Rhodolite, 3·75–3·837
Rhodonite, 3·416
Riebeckite, 3·391–3·44
Rinkolite, 3·40
Ripidolite, 2·975
Rivaite, 2·55–2·56
Riversideite, 2·64
Romeite, 5·044–5·074
Rosasite, 4·09
Roscherite, 2·916
Rumpfite, 2·666
Rutile, 4·123–4·272

Salmonsite, 2·88
Samarskite, 4·2–6·04
Samiresite, 5·24
Sarcopside, 3·64
Sarkinite, 4·173–4·178
Scapolite, 2·506–2·78
Schafarzikite, 4·3
Schallerite, 3·368
Scheelite, 5·9
Schneebergite, 5·41
Schoepite, 5·685
Schultenite, 5·943
Schungite, 1·122
Schwartzembergite, 7·39
Scolecite, 2·198–2·279
Scorodite, 2·70–3·235
Searlesite, 2·45
Seligmannite, 5·44–5·48
Sellaite, 3·17
Semseyite, 5·84–6·05
Sericite, 2·798
Serpentine, 2·528–2·61
Sheridanite, 2·702
Sicklerite, 3·45
Silica glass, 2·194–2·213
Silver, 8·33–9·83
Sincosite, 2·84
Sklodowskite, 3·54–3·74
Skutterudite, 6·519–6·79
Smithsonite, 4·19–4·410
Sobralite, 3·60
Sodalite, 2·295–2·33
Soddite, 4·627
Soumansite, 2·87
Spencerite, 3·123–3·142
Sperrylite, 10·58–10·73
Spessartine, 4·058–4·35
Sphene, 3·411–3·499
Spinel, 3·682–3·924
Spodumene, α-, 2·997–3·301
— β-, 2·317–2·463
— γ-, 2·313
Stasite, 5·03
Staszicite, 4·227
Staurolite, 3·753–3·778
Stevensite, 2·15–2·20
Stewartite, 2·94
Stichtite, 2·161
Stibnite, 4·651–4·654
Stilbite, 2·116–2·21
Stilpnomelane, 2·85–2·882
Strengite, 2·84–2·86
Stromeyerite, 6·127–6·260
Strüverite, 4·91–5·036
Sulphohalite, 2·5
Sulphur (monoclinic), 2·074
Sursassite, 3·252
Svabite, 3·695
Svanbergite, 3·14
Swedenborgite, 4·285
Syngenite, 2·579
Szajbelyite, 2·76

Tabergite, 2·803
Tachyhydrite, 1·664–1·669
Talc, 2·832
Tantalite, 6·5–8·20
Tantalum, 11·2
Tapiolite, 7·190–7·91
Taramite, 3·439–3·476
— fluo-, 3·231–3·318
Tennantite, 4·576–4·746
Tephroite, 4·044
Terlinguaite, 8·723–8·728
Tetrahedrite, 4·597–5·079
Thalenite, 4·454
Thaumasite, 1·85–1·879
Thenardite, 2·67
Thomsenolite, 2·982
Thomsonite, 2·22–2·389
Thorianite, 9·33
Thortveitite, 3·55–3·571
Thuringite, 3·07
Tilasite, 3·76–3·77
Tinzenite, 3·286–3·416
Toddite, 5·041
Topaz, 3·349–3·59
Torbernite, 3·219–3·95
— meta-, 3·67–3·68
Torendrikite, 3·153–3·21
Törnebohmite, 4·94

Tourmaline, 2·978–3·250
Trevorite, 4·67–5·165
Tridymite, 2·267–2·270
Trigonite, 8·28
Trimerite, 3·404
Triphylite, 3·531
Triplite, 3·584–3·875
Trona, 2·14
Trudellite, 1·93
Truscottite, 2·47
Tschermigite, 1·645
Turquoise, 2·84
Tyuyamunite, 3·67–4·35

Ulexite, 1·91
Ullmannite, 6·70
Ultrabasite, 6·026
Uralite, 3·118
Uraninite, 7·126–9·787
Uranospathite, 2·50
Ussingite, 2·495
Uvarovite, 3·418–3·81

Vanadinite, 6·46
Variscite, 2·47
Vauxite, 2·375–2·57
Velardeñite, 3·038–3·039
Villamaninite, 4·433–4·523
Viridine, 3·202–3·238
Viridite, 2·89
Vivianite, 2·678–2·693
Voelckerite, 3·06–3·10
Vogtite, 3·39
Volgerite, 3·082
Vonsenite, 4·21
Vrbaite, 5·30

Warthaite, 7·163
Wavellite, 2·325
Weibyeite, 3·19
Weslienite, 4·964–4·971
Wilkeite, 3·234
Witherite, 4·29
Wittite, 7·12
Wöhlerite, 3·48
Wolframite, 6·93–7·49
Wollastonite, 2·897–2·992
Wurtzite, 4·087

Xanthitane, 3·04
Xanthophyllite, 3·081
Xanthoxenite, 2·844
Xenotime, 4·55
Xonotlite, 2·655

Yttrocerite, 3·61
Yttrofluorite, 3·319–3·557

Zebedassite, 2·194
Zeunerite, 3·28
Zinnwaldite, 2·916–3·018
Zircon, 4·048–4·748
Zirkelite, 4·3–5·22
Zoisite, 3·35

Addendum.—During the printing of the above numerical table some duplicate determinations for beryl have been deleted, and there is still an undue preponderance in the number of determinations for this mineral between 2·7 and 2·799. Also, since the curve (fig., p. 340) was drawn, forty-four values have been added from the last number (no. 118) of the Magazine. The result is that the peak of the curve is now at 2·65 for 196 determinations.

On β-quartz twins from some Cornish localities.

(With Plates VIII and IX.)

By Julien Drugman, M.Sc., Ph.D.

[Read June 14, 1927.]

In their paper on 'The structure of α and β quartz',[1] Sir William Bragg and R. E. Gibbs touch on the question of twinning of quartz, showing how X-ray determination of structure can help to explain the different types of twinning. They only mention, however, twinning with parallel axes and twinning on $\xi(11\bar{2}2)$. It would be interesting to see this extended to the examination of all known laws of twinning of α- and β-quartz. There is, however, still much doubt about the laws of the twinning of quartz. Many varieties of twins have been described, but a number of these are much open to doubt, while some are decidedly non-existent. G. Friedel [2] has within recent years published valuable papers on the laws of twinning in general, and has made more special application of his theories to the laws of twinning of quartz. It would be interesting to see how far all cases of well-established quartz twins occurring in nature confirm his results.

I, myself, have been mainly interested in the twin-laws of β- or high-temperature quartz, and have often tried to find a locality where material would be in sufficient abundance to yield, after systematic search, examples of all laws that might possibly occur in such quartz. It seems to me necessary, when studying their twin-laws, to treat α- and β-quartz separately. The latter generally occurs as well-developed bipyramidal crystals. Their formation in the fluid magma, uninfluenced by contact with walls and other impedimenta that affect the regularity of α-quartz, makes irregular interpenetrations an exceptional occurrence. Such irregular intergrowths are certainly met with, but only as rarities, and they can generally be easily distinguished from the parallel growths or

[1] W. H. Bragg and R. E. Gibbs, Proc. Roy. Soc. London, Ser. A, 1925, vol. 109, pp. 405–427.

[2] G. Friedel, Compte Rendu des Sociétés Savantes, 1920, pp. 92–120; Bull. Soc. Franç. Min., 1923, vol. 46, pp. 79–95; Leçons de Cristallographie, 1926, pp. 457–460.

twinned elements on the specimens. Amongst the thousands of crystals from the Esterel Mts. that I have examined, only five cases of unidentified groupings could be found; in the more complex Cornish specimens about a dozen, and some of these may eventually prove to be twinned on a definite law. A great disadvantage attached to the study of these crystals is the roughness of their faces, only approximate measurements being possible. The goniometer is not of much use, and most of the measurements were made on the rotating microscope-stage, to degrees or, at best, to half degrees. A few specimens from Wheal Coates, out of the hundreds found, had faces smooth enough for measurements to be possible when fragments of cover-glass were gummed on them. These all confirmed diagnostics previously arrived at by the more primitive methods.

My attention had been brought to the possibility of good material being obtainable in Cornwall by the presence of twins amongst specimens of porphyry-quartz in the Oxford mineral collection that had been collected by Prof. H. L. Bowman at Wheal Coates near St. Agnes. When I joined the Society's jubilee excursion to Cornwall in 1926, I had such quartzes in mind. Unfortunately we did not get to Wheal Coates, but I was fortunate enough to find some twinned bipyramids scattered over the surface of the soil near Belowda Beacon. Time was short, but during the available couple of minutes 47 crystals were collected, 26 of which were twinned.

Thanks to the kindness of Sir John Flett, who re-visited the locality and collected a quantity of these bipyramids, I was able to start a more systematic study of the material. Later on, Sir John Flett sent me another lot, that had been collected by Mr. Wm. Boxhall, of St. Austell, in an abandoned clay-pit, close to Belowda Beacon. These are large and generally formed of a number of parallel elements, but well developed. They gave promise of still better material for study, and I finally decided to go myself and collect as large a number as possible. With Mr. Boxhall's assistance, I was able to collect several hundred specimens, among them some of the largest I have seen from any locality. Being within easy reach of St. Agnes, I also visited Wheal Coates and picked up about 130 twinned specimens, besides untwinned ones.

The following description relates to twins of β-quartz from these three Cornish localities:—

1. Belowda Beacon, near Roche.
2. The abandoned china-clay pit near Belowda Beacon.
3. Wheal Coates, near St. Agnes.

The first two occurrences might be treated as one, for they seem to belong to the same rock-mass, a variety of greisen. But the process of weathering of the rock appears to differ. The Belowda Beacon specimens are found scattered over the surface of the soil, and are derived from the portion of the rock that had become disintegrated by the ordinary process of weathering. The others, on the other hand, come from the quartz-dump left as a residue of working the 'china-clay rock', that had undergone deep-seated transformation. In consequence, these latter are generally whiter and sharper than the former, which have become yellow by exposure and also show signs of attrition. Otherwise they are quite similar, though those from the clay-pit are on the average larger. Both are formed of numbers of parallel elements, but even the larger ones from the clay-pit show a perfectly definite orientation of the constituent parts, either parallel or in twin-position. Some of these are as much as an inch across.

The Wheal Coates bipyramids are sharper and less complex and much smaller than the above. They average less than a quarter of an inch across, rarely attaining half an inch in some of the more complex groups. They are found scattered on the surface of the soil and are derived from a quartz-porphyry, which also contains, in places, felsp phenocrysts. Their special characteristic is the presence of well-developed prism-faces, whereas in the other localities these are absent or only rudimentary, as is generally the case in porphyry-quartz. They are associated with abundance of tourmaline needles and prisms. The Wheal Coates specimens were the best for measurement, some being very sharp and clean-cut. But even these are not up to goniometer standard. Only a few selected crystals could be measured with glass slips gummed on their faces.

The twin-laws so far known with certainty for β-quartz have been tabulated in detail in a previous paper[1] in this Magazine (vol. 19, p. 299). They are the following:

(*a*) The 'Esterel' law; twin-plane $(10\bar{1}1)$.[2]

(*b*) The 'Verespatak' law; twin-plane $\xi\,(11\bar{2}2)$.

(*c*) The 'Sardinian' law; twin-plane $(10\bar{1}2)$.

The above-mentioned paper gives full literature references to these twin-laws. I also mentioned a supposed 'hetero-twin', also from the

[1] J. Drugman, An example of porphyry-quartz, from the Esterel Mts., France, twinned on face $(10\bar{1}2)$. Min. Mag., 1922, vol. 19, pp. 295–300.

[2] Previously called '*R*-twins', but this is not a satisfactory designation for β-quartz, which is hexagonal and not trigonal.

Esterel Mts., and described by F. Zyndel. I have, since then, had reason to doubt whether there are such things as 'hetero-twins'; and G. Friedel, in one of his papers mentioned above, specially shows that the supposed hetero-twins of quartz are probably non-existent.

The only other references to twinning of β-quartz is by H. Wedding,[1] who found a crystal among some that had been given him in Cornwall (and described as small bipyramids from near St. Agnes) that might be twinned on (30$\bar{3}$1). G. Rose, who saw the crystal, agreed that it might be such a twin, but that it needed confirmation. The law, in itself, is doubtful. As will be shown below, another explanation can be given of this supposed law; an explanation, I find, also suggested by E. Balogh.

The Sardinian law is theoretically well founded, yet no specimen has been obtained of it amongst the Cornish material. On the other hand, four other modes of grouping occur with certainty there. These will be described farther on.

As regards frequency of twinning in these Cornish specimens, roughly, one cluster in three shows twinning. This is, at first sight, a large proportion; but, taking into account the large number of parallel elements that make up each bipyramid, one can conclude that twinned parts occur, perhaps two or three to the hundred, a proportion comparable with that observed in the Esterel specimens. Twinning with inclined axes is, in any case, a normal occurrence in high-temperature quartz, and not merely an occasional freak.

Of the commoner laws, Esterel twinning is about twice as frequent as ξ-twinning, here as well as in the Esterel Mts. Of about 1,500 Cornish specimens first examined, about 600 were Esterel-twinned and 300 ξ-twinned, besides some 35 of other orientations and a dozen chance intergrowths. The rest showed only parallel growths. A second collecting tour, since reading this paper, confirms these proportions, besides yielding still another new law in some dozen specimens.

A. *Twinning on* (10$\bar{1}$1); *'Esterel' twinning.*

As in the Esterel Mts., this mode of twinning occurs in perfectly symmetric assemblages of two equal crystals, with composition-plane roughly parallel to the twin-plane. Plate VIII, nos. 1–2 and 7–8, show examples of this symmetric form. In these complex assemblages, however, the symmetric development is rather the exception. In the majority of specimens, a small crystal is seen on a pyramid face of a larger one

[1] H. Wedding, Zeits. Deutsch. Geol. Gesell., 1861, vol. 13, p. 139.

with one face parallel, but its apex pointing in the opposite direction. This may be repeated several times on the same specimen. As many as eight twinned portions have been seen on a single specimen. Associations of two or more twins of approximately equal crystals are also frequent, and lead to all sorts of puzzling groups. It will be sufficient to describe the more interesting ones.

Triplets of three nearly equal crystals occur, in which one crystal is Esterel-twinned on two alternate upper faces with the other two, giving a very symmetric-looking assemblage. The other two crystals have, how-

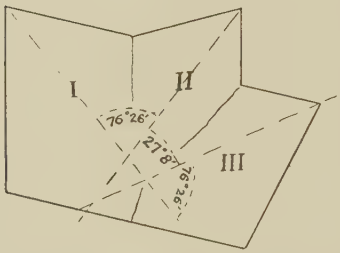


Fig. 1.

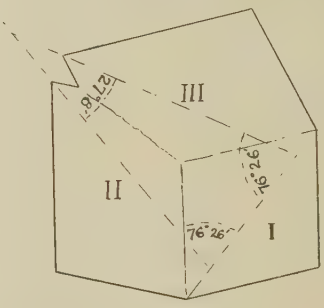


Fig. 2.

Repeated Esterel-twins of β-quartz (simulating twinning on $(30\bar{3}1)$).

ever, no definable orientation towards each other. Plate VIII, no. 11, gives an example of this association. An example of repeated Esterel twinning is shown in pl. VIII, no. 3, in which faces $(10\bar{1}1)$ and $(10\bar{1}\bar{1})$ of the middle crystal act as twin-planes. In this case, the two outer crystals also have the appearance of true twinning, for the axes of all three crystals are in one plane and they have the zone $[(10\bar{1}0), (10\bar{1}1)]$ in common. Another example of the same mode of association, but of somewhat different development, is shown in pl. VIII, no. 14. The lower crystal on the left is Esterel-twinned with each of the other two. These two have quite the appearance of a symmetric twin whose c-axes are at approximately 30° to each other. This is, I am convinced, the true explanation of the supposed twin on $(30\bar{3}1)$ described by Wedding. Figs. 1 and 2 give, diagrammatically, the relation of the three crystals in these two groups. It will be seen that the angle between the c-axes of the two crystals is 27° 8′, whereas twinning on $(30\bar{3}1)$ requires an angle of 29° 24′. This difference is quite within the limits of error in measuring such rough crystals. E. Balogh also describes such a group and comes to the same conclusion. No example of a genuine twin on $(30\bar{3}1)$ has

yet come to my notice in spite of the abundance of the material collected by me at the place Wedding's supposed twin is said to have come from. I have yet another example of this grouping which has still more the appearance of a twin of two crystals with *c*-axes at about 30°. The crystal which acts as link for the other two is reduced to a minimum and appears only in the upper re-entrant angle, wedged in between these.

Another interesting example of repeated Esterel twinning is one in which two parallel faces of the middle crystal act as twin-planes. The two outer ones are, therefore, parallel to each other, and the group has a zigzag development, like a repeated albite-twin or some rutile twins. The other cases observed call for no special mention.

B. *Twinning on* $\xi(11\bar{2}2)$; *'Verespatak type'.*

Symmetric twins are also found here. Plate VIII, nos. 4–6 and 9–10, give examples of these. They are the exception, however, unsymmetric development being much more frequent. Generally, a small crystal is seen astride the edge of a large crystal, the adjacent pair of faces being parallel in both, but the apex of the small crystal pointing away from that of the larger one. The position of the smaller crystal can, however, be any other, in which case it is not easy to recognize at once the mode of twinning. Holding the large crystal upright, with the apex of the smaller one pointing towards the observer, the true relation of the two is readily seen. As with Esterel twinning, this law is often seen several times on the same group, giving rise to symmetric-looking assemblages. When this occurs on two alternate upper edges of the link between the other two crystals, triplets very similar to those of two Esterel-twins are formed (pl. VIII, no. 12). Triplets are also observed of an Esterel- and a ξ-twin (pl. VIII, no. 13). Another interesting case is that in which the two adjacent upper edges of the link act as twin-planes. The other two crystals almost look like an Esterel-twin. There is, however, of course, no relation between them in actual fact.

In one case of repeated ξ-twinning, in which faces $(11\bar{2}2)$ and $(\bar{2}112)$ of the one crystal act as twin-planes, this middle crystal is also almost invisible, and a group of, apparently, two equally developed crystals somewhat similar to a twin on $(21\bar{3}1)$ is obtained. There is, however, a sufficiently large difference in orientation to exclude this interpretation of the group, even though the link had been quite invisible.

Some specimens, which might be called 'stringers', show a series of crystals following each other approximately in the same direction, yet all twinned according to some definite law. One such stringer is formed

of five crystals. 1 and 2 are Esterel-twinned, 2 and 3 ξ-twinned, 3 and 4 Esterel-twinned, and 4 and 5 Esterel-twinned, all in fairly symmetric twinning. In fact, the associations of these two laws with each other are about as numerous as those of two or more twins of the same law. They are also often found associated with the following rarer and new twin-laws.

C. *Twinning on* $(30\bar{3}2)$.

Although no specimen of the Sardinian law was found in these crystals, some had, at first sight, been presumed to be such, especially two that

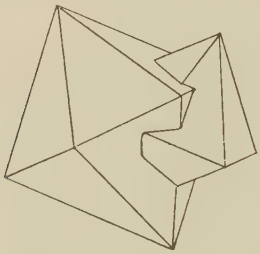


Fig. 3 *a*.

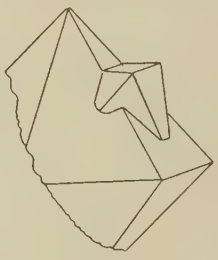


Fig. 3 *b*.

β-Quartz twinned on $(30\bar{3}2)$. (*a*) Symmetric development from Esterel Mts. (*b*) Unsymmetric development from Cornwall.

appeared identical in orientation with a crystal from the Esterel Mts. that had never been measured, but had been supposed to follow this law, being decidedly not an Esterel-twin. These two Cornish specimens were measured and gave concordant readings, but, instead of the 64° expected for the angle between the *c*-axes, an angle between 55° and 56° was found. The Esterel specimen was, therefore, also measured and gave an angle of about $55\frac{1}{2}°$. Two other crystals gave similar results; one, however, is so rough that its measurement is less certain. Enough examples, however, gave the same reading for this value to be accepted. To be quite on the safe side, the specimen of the Sardinian law, that I had previously described in this Magazine, was remeasured and the angle again found to be near 64°. The Sardinian law exists, without doubt, but another mode of twinning, with twin-plane in the same zone as those of the Esterel and Sardinian laws, also exists. The twin-plane was found to be the face $(30\bar{3}2)$ for which the angle between the *c*-axes is 55° 24′. This is in good agreement with the values observed. The law, too, is one of those predicted by G. Friedel as of likely occurrence, its 'index' being 4 and 'obliquity' 4° 43′. It is interesting to find this law at

three different localities, for, of the Cornish specimens, two were from Belowda Beacon china-clay pit and the others from Wheal Coates. The first were of unsymmetric development, but the Esterel specimen and at least three from Wheal Coates are symmetric. Fig. 3 *a* shows the symmetric and 3 *b* the unsymmetric development. Two of the Wheal Coates specimens are also shown in pl. IX, nos. 15 and 16, and that from the Esterel Mts. in no. 17.

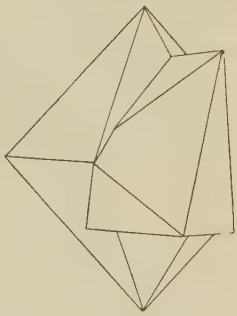


FIG. 4.

β-Quartz twinned on (20$\bar{2}$1); from Belowda china-clay pit, Cornwall.

D. *Twinning on* (20$\bar{2}$1).

A number of other specimens, both from Belowda and from Wheal Coates, had also quite the characteristics of true twinning with twin-plane also in the same zone as Esterel-twins, but the *c*-axes meet at a much smaller angle (fig. 4). The best Belowda specimens were first measured and gave concordant results, with an angle of 42° to 43° between the *c*-axes. This was confirmed by measurements of a specimen from Wheal Coates. In itself, this specimen would not be very conclusive, for it is at the same time Esterel-twinned, the three axes all lying in one plane. In conjunction with the Belowda specimens, however, the measurements can be accepted as reliable. The following table gives the measurements found in the zone of the twin-planes, while fig. 5 shows the development of the group.

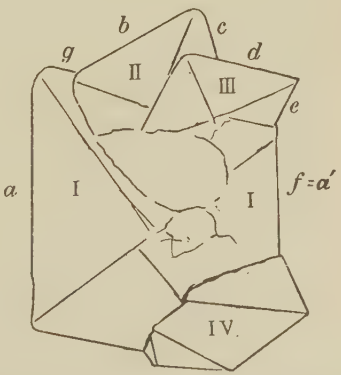


FIG. 5. β-Quartz twinned on (20$\bar{2}$1) and on (10$\bar{1}$1); from Wheal Coates, Cornwall. (I–III and I–IV Esterel-twins; II–III twinned on (20$\bar{2}$1).)

Angle between.	Found.	Theory.
a-*g*	77 °	76° 26′
e-*f*	26½	27 08
e-*d*	76½	76 26
d-*b*	43	42 58
b-*c*	76¼	76 26
c-*d*	60¾	60 36
a-*b*	60	60 36

The theoretical angles given in the second column are calculated for Esterel twinning and twinning on (20$\bar{2}$1), for this is the law whose

characteristics agree with those found on these specimens. The angle of the axes is 42° 58′, well within the limits of error for the values actually found. There is no doubt that this law exists; it is, again, one predicted by G. Friedel. Since measuring these crystals, I have found others at Wheal Coates that confirm the law. Measurements of a number of other specimens, however, complicated matters, for a number of these and a majority of the most symmetric-looking ones from Wheal Coates gave another set of values, oscillating between 36° and 40°, but most of them near 37° and 39°. A two-circle measurement of the best of these, a very symmetric specimen with faces suitable for gumming slips of cover-glass on them, confirmed the existence of another group, other than this new law on $(20\bar{2}1)$, yet so close that it appears at first improbable that both should exist. This other grouping seems to agree with the characteristics given for the Zinnwald-law; axes at 38° 13′, which brings the face $(10\bar{1}1)$ of one crystal in parallelism with $(1\bar{0}10)$ of the other. In a number of the specimens measured and which gave angles near this value, the parallelism did not seem very close. As E. Balogh also found specimens of this nature at Verespatak, one must conclude it is an easily-formed group. Yet the definitions given for it by G. Jenzsch, as also by Goldschmidt, rest on no scientific basis, for they rely entirely on the coincidence of certain faces, losing sight of the fact that it is the internal atomic structure that regulates both the relative importance of a face and twinning. Only when the internal structure can bring coincidence between the ultimate elements can twinning occur. This is a case where the results of X-ray examination of structure could bring out the true nature of the mode of grouping.

Only one specimen measured (neglecting one that gave an angle between the *c*-axes near 36°, but which shows traces of dislocation in such a direction that the specimen may, originally, have had an angle near 38° or 39°) diverges at all widely from these two means of $42\frac{1}{2}°$ and 38°. Here, a small crystal is attached unsymmetrically on a face of a larger one, but they also have a prism-pair normal to the plane containing the *c*-axes, as in the other specimens. In this specimen the angle between the *c*-axes is about 48°, not near any probable twin-plane, and, in any case, it is an isolated specimen of doubtful orientation. I only mention it for completeness and because there seems such a strong tendency for the formation of twins, especially in this zone. Incidentally, it might be mentioned that a combination of an Esterel-twin and one on $(30\bar{3}2)$ would give an angle of 48° 10′, but no external trace of such combined laws is visible on the specimen.

E. *Twinning on* $(21\bar{3}1)$.

Besides the examples described above, all of which, except the Verespatak type, have their twin-planes in the same zone, two other modes of twinning were determined in the Cornish material. These have their twin-planes in another zone. In one, the twin plane is $(21\bar{3}3)$, in the other $(21\bar{3}1)$. The latter was discovered in the material collected since reading this paper. As it seems a more important one than the other, fifteen examples of it having been found, I will describe it first. One or two specimens had been collected already on my first trip, but, without more confirmatory evidence no definite interpretation of them could be arrived at. The occurrence of so many of the same nature made it evident that there was some genuine law responsible for their formation.

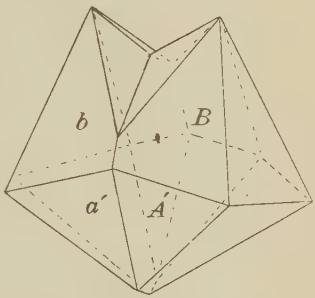


FIG. 6.
β-Quartz twinned on $(21\bar{3}1)$; from Wheal Coates, Cornwall.

Their characteristics deviate from those of twins on $(20\bar{2}1)$ in a similar way to that in which twins on $(21\bar{3}3)$, to be described farther on, deviate from twinning on $(10\bar{1}1)$. A possible twin-plane was therefore looked for somewhere in the neighbourhood of $(20\bar{2}1)$ and near the zone of $[(21\bar{3}0), (21\bar{3}3)]$. Finally, twinning on $(21\bar{3}1)$ was found to show the characteristics of these specimens. The *c*-axes are rather over 30° apart and the faces a' and A' are nearly in a plane, while b and B meet at a biggish angle (fig. 6). This is the case in twinning on $(21\bar{3}1)$ where the axes meet at 33° 8′. One crystal was found suitable for measuring with cover-glasses fixed on to its faces and a two-circle measurement was carried out of all six upper faces of each crystal. The larger individual is at the same time Esterel-twinned with another crystal, but the two portions do not interfere with each other. The Esterel-twin was also measured, the larger crystal being set up with its *c*-axis vertical. The measurement entirely confirmed this law, the deviations being even less than for the Esterel-twinned crystal. In this special case $(12\bar{3}1)$ was the twin-plane actually found. But other specimens show the other orientation. It is interesting to note that this, again, is one of the laws predicted by G. Friedel, with 'index' 6 and 'obliquity' 2° 55′. Fig. 6 gives an idealized elevation of the group, while pl. IX, no. 21, shows one orienta-

tion, and nos. 22 and 23 the other. All three crystals are from Wheal Coates.

F. *Twinning on* $(21\bar{3}3)$.

I had found a specimen among the Esterel bipyramids, some years ago, that seemed to be a twin, but, having no other specimen of the same kind, I had kept it for future examination. It seemed to have characteristics between those of a ξ-twin and those of an Esterel-twin. It looked very much like a symmetric ξ-twin that had received a sideways

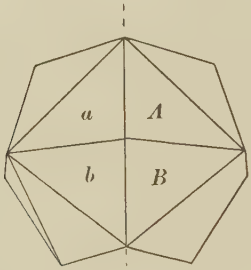


Fig. 7 *a*

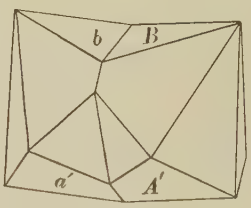


Fig. 7 *b*.

β-Quartz twinned on (2133); from Cornwall and Esterel Mts. (*a*) Plan (the dotted line is the trace of twin-plane). (*b*) Elevation.

twist, but there was no trace of any dislocation or displacement. One of the specimens from Belowda Beacon had exactly the same disposition, and, being also a well-formed specimen, I studied it more closely and compared it with the Esterel specimen. There was no doubt about their being of identical structure. They seemed to follow a law intermediate between Esterel- and ξ-twinning, and I finally found that twinning on (2133) gave an assemblage having these characteristics. Four faces slope together on the upper side of the group; those marked *a* and *A* are almost in one plane (figs. 7 *a* and *b*), while the other two, *b* and *B*, meet at an angle near 15°. This is the case for twinning on (2133). The theoretical angle between the *c*-axes is 83° 32′, which agrees with that observed and accounts for the similarity between this twin and a ξ-twin in which the angle is 84° 34′. Since describing these specimens I have found a third example that still further confirms the law. It must be an exceedingly rare one, however, and only be capable of formation under the exceptionally favourable conditions in which all these numerous twins were able to develop. The three specimens are all shown on

pl. IX. No. 24 is the first one found at Wheal Coates. No. 25, also from Wheal Coates, is not so well developed, but the law is still easily recognized; it is shown from below for comparison with the ξ-twin shown in the same way in no. 10 of pl. VIII. It will be seen that the edges, between the pair of faces of each crystal that meet at the junction, run in the same direction in the ξ-twin, whereas in this law they meet at an appreciable angle. No. 26 is the Esterel specimen, a two-circle measurement of which fully confirmed the law.

G. *Doubtful Twins.*

Of the remaining few specimens, some seem as though they might also be genuine twins, but they are isolated cases and not sufficiently perfect for measurements to confirm any definite law. They may belong to a series of twins with twin-faces in the same zone as $\xi\,(11\bar{2}2)$ and $s\,(11\bar{2}1)$. The second one, twinning on s, is known in α-quartz as Breithaupt's law or the 'Zwickau law', and is a very probable one. The angle between the c-axes is 48° 54′. A specimen from the Esterel Mts. showed an angle somewhere between 48° and 50°, but I cannot certify it, even between these wide limits. Two specimens from Cornwall were very roughly measured. The c-axes of the one were somewhere near 34°, the other near 62°. A rather improbable law with twin-plane $(33\bar{6}2)$ requires 33° 44′. The nearest to 62° that is the least improbable is an angle of 57° 36′ for the face $(11\bar{2}4)$. There only remain a few cases which are obviously chance intergrowths and a few nodular groups in which several of the constituent elements are not sufficiently visible for their relation to some of the more visible but apparently irregularly joined parts to be deciphered.

General Conclusions.

The relative importance of twinning with inclined axes in β-quartz, as well as the frequent occurrence of laws unknown or very rare in α-quartz, warrant an entirely separate treatment of the twin-laws for these two varieties of quartz.

In β-quartz, Esterel twinning is by far the most important, occurring about twice as often as ξ-twinning. This latter law comes next in importance.

Of those laws whose existence is rendered probable by a low 'index' and low 'obliquity' (compare G. Friedel, loc. cit.) those in the zone $[(10\bar{1}0), (10\bar{1}1)]$ seem much more capable of existence than those in the zone $[(11\bar{2}1), (11\bar{2}2)]$. It is interesting to find three of the new laws

among those rendered probable by their low 'index' and 'obliquity'; twinning on (30$\bar{3}$2), (20$\bar{2}$1), and (21$\bar{3}$1) being among the first that might be expected, according to G. Friedel. The Zinnwald law seems of easy formation, but it will need a more satisfactory definition to render it acceptable.

The small number of specimens found of twinning on (21$\bar{3}$3) shows that this is a much rarer law than the others. (Since writing the description of the law, however, I found another, very large and sharp, but less symmetric, specimen amongst the ξ-twin lot of my Esterel material.) The same might be suggested for the Sardinian law, but the nearness of other laws possibly interferes with its more frequent formation.

The main conclusion I have arrived at, after examination of this material, however, is that more useful progress can be obtained by systematic study of even second-rate material, if it be abundant, than by the description of a few exceptionally good specimens, that may turn out later to be but chance conjunctions. The cases on which the idea of 'hetero-twinning' is based are somewhat of that nature. G. Friedel has pointed out that the normal interpretation of Breithaupt's law or the Zwickau law is quite sufficient, without any new theory. The same applies to Paul and Goldschmidt's[1] description of a 'hetero-twin' of orthoclase. From their description of it, I have no doubt that it is caused by the simultaneous presence of two laws, the Carlsbad and Baveno laws, which, as I have shown in the Esterel andesines, lead to groups in which the middle member, that acts as link for the other two, is often quite invisible. The same groupings have been observed at Four-la-Brouque in Auvergne[2] and at Zarzalejo near Madrid,[3] but these have been described in rather indefinite terms. I have myself collected such twinned crystals of orthoclase at Zarzalejo that are quite comparable to the 'Carlsbad-Baveno' combination found in the Esterel andesines. And it is shown in the present paper that combined law groups also occur in quartz, such as might give rise to ideas of 'hetero-grouping'. It is doubtful whether the Zinnwald grouping is due to such a double law, although there is a possibility of this. A combination of the Esterel law and the Sardinian law would, for instance, give a group of three crystals in which the *c*-axes of the outer two crystals would be at 38° 44′.

[1] F. Paul and V. Goldschmidt, Orthoklas-Heterozwilling. Zeits Kryst. Min., 1909, vol. 46, p. 471.

[2] A. Lacroix, Min. de France, 1896, vol. 2, p. 89; 1910, vol. 4, p. 815.

[3] L. Fernández Navarro, Bol. R. Soc. Española Hist. Nat., 1919, vol. 19, p. 137. [Min. Abstr., vol. 1, p. 13.]

No visible trace of this association can be observed, however, on the numerous specimens found; and the fact that no specimen of the Sardinian law was noticed amongst the Cornish crystals is, also, against such an explanation. A measurement of the extinction-angles in a section through one of these groups might give information on this point, but the three-fold grouping may only exist at one small point in the interior of the crystal. The section might, very possibly, not be cut so as to include this point, and the result would still be indefinite. The suggestion made by Prof. G. Friedel, that X-rays could be used to elucidate the true nature of this group, seems to me the most likely to lead to positive results. Such 'hetero-twins' as are assimilable to parallel growths of two different substances in definite orientations would still be possible, but this condition would at once imply coincidence of the intimate particles at the contact, and we are brought back to the existence of a twinning plane or axis.

Addenda: Since the above was written a paper by J. Bindrich,[1] on porphyry-quartz twins, has been brought to my notice. This paper raises several points that can usefully be discussed here. Beside Esterel and Verespatak twinning, he observed two examples of the Sardinian law and gives confirmatory measurements of them. This law not having been observed in Cornwall, it is interesting to find it confirmed in other porphyry-quartzes. Bindrich has, however, overlooked the fact that an example of the Sardinian law, from the Esterel, was described in this Magazine in 1922. He also observed two examples of the Zinnwald grouping, giving Jenzsch's rather misleading definition of 'twinning on $(11\bar{2}0)$'. He observed no other laws, although he mentions in a final paragraph a number of cases of supposed 'hetero-twins'. Some of these may possibly be found to follow one or other of the laws mentioned in this paper.

Another point seems to need discussion. He divides his Esterel-law specimens into groups, according to the direction of the contact surface. In these porphyry-quartzes it is unwise to lay stress on the direction of this surface. The change in orientation of the intimate particles, that gives rise to a twin, took place at one small point, during the growth of the crystal. After that, each portion of the twin may be looked upon as growing independently of the other. The contact-surface depends, then, entirely on a number of external influences and does not represent the true composition-plane of the twin at its point of inception. One of the

[1] J. Bindrich, Centralblatt Min., Abt. A, 1925, 203-210. [Min. Abstr., vol. 3, p. 378.]

results of this independent growth of the parts is that the individual portions can be readily separated from each other. In the Esterel twins that have thus become separated, the contact, where it is truly plane, is always parallel to $(10\bar{1}1)$. Designation of types on this basis leads to much complication and confusion. This is another reason that makes it preferable to separate twinning of β-quartz from that of α-quartz, otherwise we have such designations as 'the Esterel type of the Reichenstein-Griesernthal law' and have to further define which of the two latter divisions it belongs to, &c.

An attempt is therefore made here to simplify matters by treating both varieties of quartz quite independently and reserving for porphyry-quartz special names for each law. The other laws having been generally identified with the locality where they were first observed, I would suggest the following designations for all twin-laws so far observed in β-quartz. (Only twin-planes are mentioned and not axes, the former being sufficient, in all the cases mentioned, to define the law.)

Laws of twinning for β-quartz.

Angle between the c-axes.	Twin-plane.	Name of law.	Remarks.
84° 34′	$(11\bar{2}2)$	'Verespatak' law	Rather than the 'Verespatak' type of the Gardette or Japanese law.
76 26	$(10\bar{1}1)$	'Esterel' law	The first description published was that of the Esterel specimen.
115 10 (64 50)	$(10\bar{1}2)$	'Sardinian' law	This name is retained, having already been used in former papers. The original specimen may have been of α-quartz, but its true twin nature, even, is doubtful.
55 24	$(30\bar{3}2)$	'Belowda Beacon' law	First identified from Belowda Beacon and confirmed from the Esterel and Wheal Coates.
42 58	$(20\bar{2}1)$	'Cornish' law	Found both at Belowda Beacon and Wheal Coates.
33 8	$(21\bar{3}1)$	'Wheal Coates' law	So far, not observed elsewhere in good specimens.
83 30	$(21\bar{3}8)$	'Pierre Levée' law	First observed on a specimen from the Esterel, near 'Pierre Levée'. The best example is from there.

I am still leaving aside the Zinnwald grouping until a satisfactory definition can be given for it. As previously stated, the angle between the c-axes is 38° 13′, half that for Esterel twinning. The rather doubtful

existence of Wedding's supposed law on (30$\bar{3}$1) makes it advisable not to include it here; if it were found really to exist, it might be termed the 'St. Agnes' law. It is very probable that this list will be added to in the future, several laws being still possible, e. g. Breithaupt's law (Zwickau law).

In conclusion, I wish to express my best thanks to Sir John Flett, without whose help it would have been quite impossible for me to obtain the material to start this work. He collected, himself, valuable material and interested others in searching for still better. To Mr. William Boxhall I am indebted for the material from the china-clay pit near Belowda Beacon, and to Prof. H. L. Bowman for very kindly giving me detailed information for finding the Wheal Coates material. I would also like to mention Prof. G. Friedel, who has done so much to clear the question of twinning in quartz; and also to thank him for the kindly personal advice which he has given to me when any special difficulty arose.

Explanation of the Plates VIII and IX.

Plate VIII:

A. β-Quartz twins from Belowda Beacon china-clay pit, Cornwall (enlarged 1·4 diam.).

Nos. 1 and 2. 'Esterel' twinning; very symmetric in no. 1; somewhat less, owing to parallel growth, in no. 2.

3. Repeated 'Esterel' twin; the three *c*-axes in one plane. I–II, II III are Esterel twinned; I–III simulate twinning on (30$\bar{3}$1).
4. 'Verespatak' twinning; twin-plane (11$\bar{2}$2).
5. The same, less symmetrically developed.
6. The same, seen from below. (Compare no. 25, pl. IX.)

B. β-Quartz twins from Wheal Coates, Cornwall (enlarged 2·3 diam.).

7. Esterel twin of symmetrical development.
8. The same; one crystal complicated by parallel growth.
9. 'Verespatak' twin.
10. The same, seen from below. (Compare no. 25, pl. IX.)
11. Triplet of two 'Esterel' twins (I–II and II–III Esterel twins).
12. Triplet of an 'Esterel' twin (I–III) and a 'Verespatak' twin (I–II).
13. Triplet of two 'Verespatak' twins (I–III and II–III).
14. Two 'Esterel' twins, simulating a twin on (30$\bar{3}$1). I–II and I–III are Esterel-twinned; II–III simulate a twin on (30$\bar{3}$1).

Plate IX: Rarer twin-laws of β-Quartz (enlarged 2·5 diam.).

Except nos. 17 and 26 from the Esterel Mts., France, these are all from Wheal Coates, Cornwall.

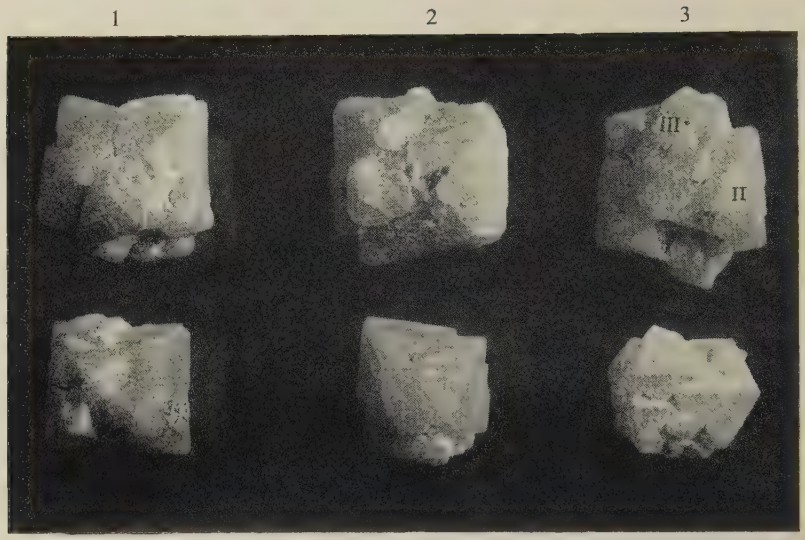
Nos. 15–17. '*Belowda Beacon' law*; twin-plane (30$\bar{3}$2). No. 15 is at the same time Esterel-twinned, the small crystal below being Esterel-twinned with the left-hand one of the main group. No. 17, from the Esterel Mts., is a twin on the 'Belowda Beacon' law given here for comparison.

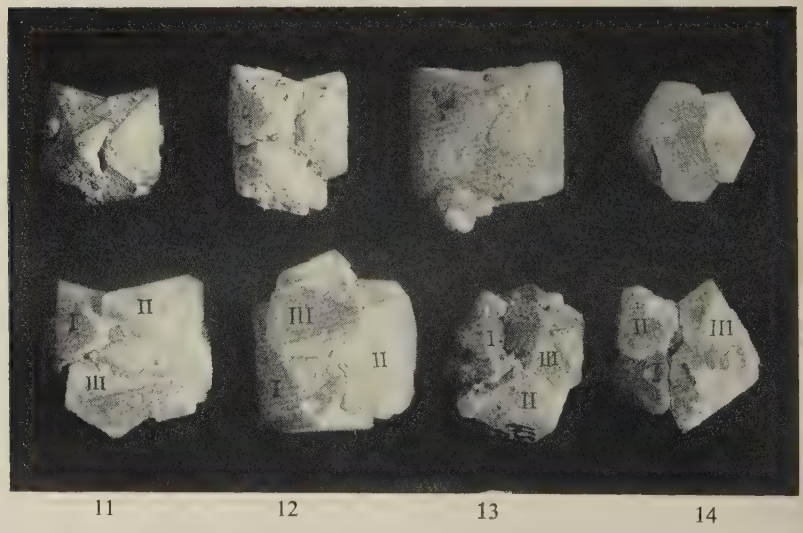
18. Twin on '*Cornish' law*; twin-plane (20$\bar{2}$1).

19 and 20. '*Zinnwald law*' (?). The angle is very close to that of the previous law. They can hardly be distinguished from each other except by careful measurements.

21–23. '*Wheal Coates' law*; twin-plane (21$\bar{3}$1) and (12$\bar{3}$1). No. 22 is set up with the twin-plane vertical and normal to the plate; nos. 21 and 23 are set up with one crystal upright. It will be seen that the second crystals in 21 and 23 are orientated symmetrically with respect to each other; the twin-plane in the first being (21$\bar{3}$1), and in the second (12$\bar{3}$1).

24 26. '*Pierre Levée' law*; twin-plane (21$\bar{3}$3). All three specimens are symmetrically developed. No. 25 is seen from below, for comparison with the two ξ-twins nos. 6 and 10 of pl. VIII. In this law, the edges between the pair of faces that meet at the junction of the two crystals meet at a fairly wide angle, while in ξ-twinning they run from one crystal to the other in a straight line.





J. DRUGMAN: β-QUARTZ TWINS FROM CORNWALL.

J. DRUGMAN: β-QUARTZ TWINS FROM CORNWALL.

Notice of an occurrence of niccolite and ullmannite at the Settlingstones mine, Fourstones, Northumberland; and of serpierite at Ross Island mine, Killarney, Co. Kerry, Ireland.

By Arthur Russell.

[Read January 18, 1927.]

THE old mine Settlingstones, situated three miles north of Haydon Bridge in the county of Northumberland, was originally worked as a lead mine, but, during the last fifty years, as the vein has been explored farther west, it has attained far greater importance as the largest and most consistent producer of witherite in the British Isles. The Settlingstones main vein has a direction approximately north-east and south-west, and has been proved for a distance of nearly $1\frac{1}{2}$ miles. The vein has varied in width from 3 feet up to 40 feet, the most productive witherite-bearing portion averaging 10 to 12 feet. The enclosing rocks are sandstones ('whetstones') and shales ('plate') of Carboniferous age, and dolerite (Whin-sill) which here attains a thickness of a little over 21 fathoms.

In January 1925 I received from my friend the late Mr. Sydney F. Watson, manager of the mine, specimens of niccolite which had been found there in July 1924. I at once visited Settlingstones, but unfortunately, owing to a heavy fall of ground and influx of water, the spot has not since been accessible. Mr. Watson, however, furnished me with exact particulars as to the mode of occurrence. His description is as follows: 'In the 90 fathom level we discovered a "pipe" of galena yielding 15 tons to the fathom which we worked up to the 70 fathoms level in corkscrew fashion. Near the 70 fathom level we discovered the niccolite lying by the side of the galena and next to the Whin-sill side or north side of the vein, the south side of the vein at this point being shale ('plate').[1] The niccolite was in a distinct string about 4 inches thick by 3 feet wide, and we worked this with the galena for about 2 fathoms,

[1] Many of the specimens I have examined have adhering grey micaceous sandstone, showing that the vein was in part enclosed by that rock.

when the collapse took place. I might mention that just before the collapse took place we found some antimonial lead, but not in very large quantities.' Mr. Watson most kindly afforded me every opportunity of looking over the niccolite, of which there was perhaps a little over half a ton raised. In view of the fact that ullmannite had been found some years ago in the 'barytes-witherite vein at New Brancepeth Colliery, Co. Durham,[1] I was particularly on the look out for this mineral, and was

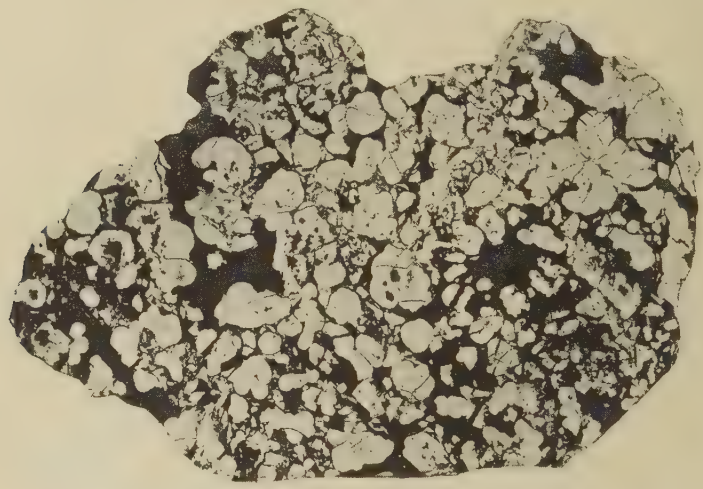


Fig. 1. Polished surface, showing roughly spherical niccolite, with blende, ullmannite, and witherite. ($\times \frac{6}{7}$.)

rewarded by finding it to be present, though in small quantity, intimately associated with the niccolite.

Typical specimens of the ore show a preponderance of niccolite intimately associated with blende, usually some galena, and very much smaller quantities of ullmannite, the interstices between the metallic minerals being filled by white witherite and sometimes a soft grey micaceous sandstone. The niccolite has the characteristic pale copper-red colour, has a finely crystalline structure, and shows a very marked tendency to assume roughly spherical forms; the exterior of some of the masses being very definitely botryoidal, with a drusy dark grey surface. The structure of the ore is beautifully shown in polished sections, which also enhance several interesting features. Fig. 1 is a photograph of a polished section showing the spherical niccolite, sometimes with a dark

[1] L. J. Spencer, Min. Mag., 1910, vol. 15, p. 302.

nucleus of blende. The dark areas are white witherite, the rather lighter, brown blende. The ullmannite is indistinguishable in this photograph from the niccolite except where it has a minutely cubical outline. The blende, which often forms a large proportion of the mass, is more or less fine-grained, has a resinous brownish-yellow colour, and does not occur crystallized. Galena is present in most specimens, but in much smaller quantity. It is for the most part segregated away from the richer

Fig. 2.

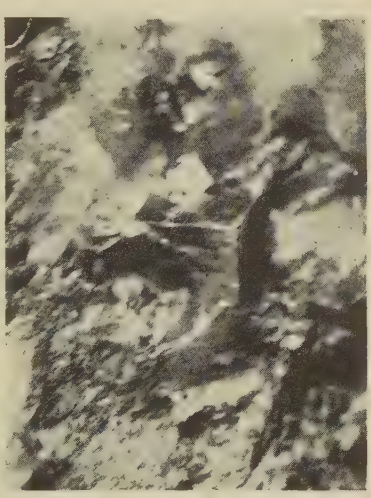


Fig. 3.

Fig. 2. Polished surface, showing cubes of ullmannite in witherite (dark), with niccolite. (×18.)

Fig. 3. Cubes of ullmannite, with witherite, and niccolite. (×18.)

masses of niccolite which only show occasional small strings of galena in the polished specimens. Some of the rich masses of niccolite from the side of the vein show slickensided surfaces with a thin coating of galena. Ullmannite appears in relatively small quantity, but is present on practically all the specimens examined. In the polished sections the mineral is seen to form irregular fringes around the niccolite and strings running through it, and also more rarely as minute cubes in the groundmass of witherite. Fig. 2 is a photograph of a part of the polished section shown in fig. 1, under a higher magnification. The small isolated masses are ullmannite, one of which is a distinct cube, the dark groundmass is witherite, and the large light-coloured masses are niccolite. On a few specimens are very small, bright silver-white, and well-defined inter-

penetrating cubes of ullmannite, projecting from the white witherite, and it was upon these that a qualitative chemical test was made to determine the nature of the mineral. The largest crystal observed has a diameter of about 1 mm. No forms other than the cube are present. Fig. 3 shows one of these isolated cubes with the characteristic pyrite-like striations. Minute crystals of pyrite were observed on the surface of one of the masses of niccolite-blende ore. I have not been able to obtain a specimen of the 'antimonial lead' mentioned by Mr. Watson, and it is therefore impossible to say whether the antimony was present in the galena or as an admixture of ullmannite. The occurrence of niccolite in a witherite vein in rocks of Carboniferous age is interesting, and the specimens are by far the best examples of the species so far met with in the British Isles. My especial thanks are due to Mr. E. P. Deas, of the Settlingstones Company, for permission to publish this record, and to Mr. A. F. Hallimond for photographing the polished sections.

Serpierite.[1]

The rare mineral serpierite has hitherto been recorded from one locality only, the Kamareza section of the Laurion mines in Greece. In the present notes I am able to record its occurrence at the old copper mine of Ross Island, Killarney, Co. Kerry, Ireland, where, in 1914, I found several well-defined specimens on the old dumps.

The Ross Island mine[2] is situated on the southern shore of Ross Island on Lough Leane or Lower Lake, Killarney (Six-Inch Ordnance Map, Kerry 66). It had been worked at intervals from very early times, the periods of its greatest activity being 1804 to 1810 and from 1825 to 1829, since when no regular mining has been done. The copper ores were apparently exceptionally rich, and ore to the value of over £100,000 was obtained. The ores are chalcopyrite, tetrahedrite, and bornite, and they form pockets, irregular patches, and strings, along with calcite in

[1] Serpierite was described by A. Des Cloizeaux in 1881 as a hydrated basic sulphate of copper and zinc. The only quantitative analysis that has been made of the mineral is one by A. Frenzel (Tschermaks Min. Petr. Mitt., 1894, vol. 14, p. 121), who found also CaO 8·00 %. The formula was written as $3(Cu,Zn,Ca)SO_4 + 3H_2O$, and it has been so copied. This was, however, evidently intended to be $3(Cu,Zn,Ca)O.SO_3.3H_2O$. But this also is an error, for a slip was made in calculating the molecular ratios. From Frenzel's analysis the ratios are $(Cu,Zn,Ca)O : SO_3 : H_2O = 2{\cdot}21 : 1 : 3{\cdot}07$.

[2] A detailed and interesting description of this mine is given, along with a plan and section, by Thomas Weaver, F.R.S., in his Geological Relations of the South of Ireland, 1830–1835.

a thin bed of bluish-grey Carboniferous Limestone, underneath which is a bed of highly siliceous limestone completely barren of metallic minerals. There also occurred rarely native copper, cuprite (both crystallized and as tile-ore), malachite, and chessylite. Of the two former I found one specimen showing small spike-like sprigs of native copper upon which are implanted minute octahedra of cuprite, occupying a cavity in yellowish crystalline limestone. The deposit as a whole is perfectly illustrated on a small scale by hand-specimens of the ores which may be obtained from the dumps. At the eastern end of the workings is a large water-logged open-work known, from the colour of its waters, as the Blue Hole, and it was from the dump debris from this that the specimens of serpierite were obtained. The ores worked in the Blue Hole were in the northern part chalcopyrite, and in the southern a fine-grained intimate mixture of blende, galena, pyrite, and a little chalcopyrite, exactly similar to the so-called 'blue stone' of the Parys and Mona mines, Anglesey, and to ores occurring at the Ovoca mines, Co. Wicklow. Smithsonite ($ZnCO_3$) is also tolerably abundant as brownish cellular and minutely stalactitic masses, containing spots of galena and chalcopyrite, and it is in cavities of this smithsonite that the serpierite occurs; this association and the appearance of the specimens being precisely similar to that prevailing at Laurion. The serpierite forms very small greenish-blue spherical aggregates or tufts (0·5 mm. in diam.) composed of minute crystals flattened parallel to $c(001)$ and elongated in the direction of the a-axis. The crystals are too small to permit of measurement, but under the microscope they show an outline which, besides being elongated in the direction of a, suggests that they are bounded at the ends by $m(110)$. The cleavage is parallel to c, which has a distinctly pearly lustre. The mineral is optically biaxial and negative, with the acute bisectrix perpendicular to c (001). Refractive index slightly above 1·59. Pleochroism weak. A qualitative test proved the presence of Cu,Zn,Ca,SO_3 and H_2O. Other small cavities on the specimens described are lined with a pale-blue wool-like mass of very minute crystals, which also appear to be serpierite. To Mr. Campbell Smith I am indebted for the determination of the optical characters.

South African occurrences of willemite. Fluorescence of willemite and some other zinc minerals in ultra-violet rays.

By L. J. Spencer, M.A., Sc.D., F.R.S.
Keeper of Minerals in the British Museum
(Natural History).

[Read November 1, 1927.]

WILLEMITE is a mineral of comparatively rare occurrence, but it has long been mined in New Jersey as an important ore of zinc (Zn_2SiO_4, containing Zn 58·6 %), and it would seem also to be abundant in Rhodesia. In the standard mineralogies of Dana (1892) and Hintze (1889) it is mentioned from only four districts. As there is some confusion in the statement of these few localities, and further as several others have been discovered during recent years, a complete list of localities for this mineral has been compiled from the literature; and some others represented by specimens in the British Museum collection are added, including the African occurrences now to be described.

As a distinct mineral-species, willemite was first recognized in New Jersey in 1822, although it had evidently been mined there for many years before. It was then known as 'silicious oxide of zinc'. The name willemite was applied by A. Lévy in 1830 to what afterwards proved to be the same mineral. His material was found in the Netherlands, and was named after Willem (William) I (1772–1844), King of the Netherlands. It came from the small (less than 1,400 acres) neutral state of Moresnet situated between Prussia and Belgium (though the present kingdom of Belgium was not founded until that year—1830). Under the Treaty of Versailles (1919) it is now in Belgium. In this connexion it is interesting to recall that the name 'belgite' has been suggested for this mineral. R. Panebianco, writing in esperanto in 1916, objected to naming minerals after kings, preferring a name derived from the locality. He, however, overlooked the fact that the locality was not, at that time, in Belgium.

Localities of Willemite.

Mine Hill, Franklin Furnace,[1] Hardyston township, Sussex Co., New Jersey. Here are the Buckwheat (= Taylor), Parker, Trotter, and Franklin mines.

Stirling Hill,[2] Ogdensburg, Sparta township, Sussex Co., New Jersey. Two miles south of Franklin Furnace and on the same band of crystalline limestone. (L. Vanuxem and W. H. Keating, Journ. Acad. Nat. Sci. Philadelphia, 1822, vol. 2, p. 287; 1824, vol. 4, p. 8.)

Altenberg (= Vieille-Montagne),[3] Moresnet, Liége, Belgium. 8 km. SW. of Aachen. (A. Lévy, Jahrb. Min., 1830, p. 71; Ann. Mines, Paris, 1843, ser. 4, vol. 4, Mém. p. 513.)

Büsbacherberg (or Busbacher Berg), Stolberg, Aachen, Rheinland, Germany. 8 km. ESE. of Aachen, and on the same outcrop of Devono-Carboniferous rocks as Altenberg. (V. Monheim, Verh. naturhist. Ver. preuss. Rheinlande, 1848, vol. 5, p. 162. C. Hintze, Handb. Min., 1889, vol. 2, p. 35, mentions three other spots in the district between here and Altenberg, namely. Brockenberg on the German side, and Schmalgraf mine and Heggelsbrück mine on the Belgian side.)

Musartut, Tunugdliarfik fjord, Julianehaab district, Greenland. (A. Des Cloizeaux, Man. de Min., 1862, vol. 1, p. 554; O. B. Bøggild, Mineralogica Groenlandica, Meddel. om Grønland, 1905, vol. 32, p. 276.)

Merritt mine, Socorro Co., New Mexico, U.S.A. (F. A. Genth, Proc. Amer. Phil. Soc., 1887, vol. 24, p. 43; S. L. Penfield, Amer. Journ. Sci., 1894, ser. 3, vol. 47, p. 305.)

Sedalia mine, Salida, Chaffee Co., Colorado. (S. L. Penfield, 1894, loc. cit.)

Modoc Mountain, Morenci, Graham Co., Arizona. (W. Lindgren and W. F. Hillebrand, Amer. Journ. Sci., 1904, ser. 4, vol. 18, p. 451.)

Star district, Beaver Co., Utah. (R. W. Clark, Amer. Min., 1916, vol. 1, p. 89; Min. Abstr., vol. 1, p. 175.)

Konnerud, Drammen, Kristiania district, Norway. (V. M. Goldschmidt, Skrifter Videnskapssels. Kristiania, 1911, no. 1, p. 389.) Blue willemite previously described as apatite or thought to be lazulite.

Cho-Dan, near Bac-Kan, Tonkin, French Indo-China. (A. Lacroix, Min. de France, 1913, vol. 5, p. 84.)

Bou-Thaleb mine, SW. of Sétif, Constantine, Algeria. (A. Lacroix, Bull. Soc. Franç. Min., 1900, vol. 23, p. 255.)

[1] So named from the iron furnace where cannon were cast during the American war of independence (1775–1781). It is also known as Franklin, both names being in common use. At the time of my visit in 1924, the railway station was labelled 'Franklin Furnace' and the post office 'Franklin'. The name Franklin Furnace is here adopted, since Franklin is a very common place-name in the United States, there being, for instance, at least six other such places in New Jersey alone.

[2] Also spelt Sterling Hill, but evidently named after William Alexander (1726–1783), titular Earl of Stirling, a former owner of the land. He sent several tons of 'red ore' from there to England for the manufacture of brass about 1774; i. e. long before zincite was recognized as a mineral-species. 'Sparta', the name of the township, is sometimes quoted as the locality for willemite.

[3] Given in some of the old books as 'Old Mountain in Limburg'.

Jebel Reças (Ressas) mine, 25 km. SE. of Tunis, Tunisia. (A. Lacroix, Min. de France, 1910, vol. 4, p. 720.)

Mindouli (Minduli), Brazzaville, French Middle Congo. (A. Le Chatelier, Compt. Rend. Acad. Sci. Paris, 1893, vol. 116, p. 894. A. Lacroix, Min. de France, 1910, vol. 4, p. 720; 1913, vol. 5, p. 84, gives Tchicoumba mine, Djoué mine, and Pimbi in this region.)

Tshiniama river, tributary of the Lubi, Belgian Congo (lat. 6° S., long. 23° E.). (H. Buttgenbach, Mém. Soc. R. Sci. Liége, 1927, ser. 3, vol. 14, no. —, p. 9; Min. Abstr., vol. 3, p. 351.)

Broken Hill, Northern Rhodesia. (H. Buttgenbach, Ann. Soc. Géol. Belgique, 1919, vol. 42, Congo annexe, pp. c 8, c 12; Min. Abstr., vol. 1, p. 69. See also below.)

Near Sable Antelope mine, Mumbwa, Kafue district, Northern Rhodesia. (British Museum collection; see below, p. 393.)

Near Lusaka, Northern Rhodesia. (British Museum collection; see below, p. 393.)

Guchab, Otavi, South-West Africa. (British Museum collection; see below, p. 394.)

Peñoles, Mapimi, Durango, Mexico. (British Museum collection, 1925; from the collection of the late H. F. Collins; analysed by J. C. Hoal, 1905.)

Sinaloa, Mexico. (British Museum collection, 1922; bought of W. Maucher of Munich.)

Other localities considered as doubtful, and which could not be verified, include the following:

Wanlockhead, Dumfriesshire, Scotland. (D. C. Glen and J. Young, List of minerals and rock specimens, in J. Armstrong and others, Catalogue of western Scottish fossils, Brit. Assoc. handbook, Glasgow, 1876, p. 162.)

Raibl, Carinthia [now in Italy]. (G. Leonhard, Handwörterbuch der topographischen Mineralogie, 1843, p. 525.)

Upper Silesia. (C. F. Rammelsberg, Chem. Min., 3. Suppl., 1847, p. 65. 'Williamit. Ein oberschlesischer Galmei'.)

Kucsaina, Serbia. (Brooke and Miller, Min., 1852.)

Temora, New South Wales. (J. C. H. Mingaye, Ann. Rep. Dept. Mines, N.S.W., 1889, for 1888, p. 200; C. Anderson, Bibliography of Australian Mineralogy, Min. Res. Dept. Mines, N.S.W., 1916, no. 22, p. 75.)

Mont Albion (Montalbion), Walsh and Tinaroo mining district, Queensland. (J. S. Berge, J. H. Brownlee, and R. C. Ringrose, Proc. Roy. Soc. Queensland, 1900, vol. 15, p. 54.)

Ygnacio and Cerro Gordo mines, Inyo Co., California. (A. S. Eakle, Minerals of California, Bull. Calif. Mining Bur., 1914, no. 67, p. 124.)

Willemite from Broken Hill, Northern Rhodesia.

The occurrence of willemite at this locality was first recorded by Prof. H. Buttgenbach in 1919.[1] I had previously, in 1908, detected its presence in the 'yellow rock', specimens of which were received from

[1] H. Buttgenbach. La calamine des ossements fossiles de Broken-Hill (Rhodésie). Ann. Soc. Géol. Belgique, 1919, vol. 42, Congo annexe, pp. c 5–c 14 (Min. Abstr., vol. 1, p. 69). Microscopical crystals of willemite and some other

Mr. Percy S. Tarbutt after the publication of my paper on the minerals of Broken Hill.[1] Other specimens representing another type of the mineral were received in the British Museum collection in 1920 and 1923.

One of the 1908 specimens of more heterogeneous appearance than the others shows a small cavity lined with minute reddish crystals of willemite. These were definitely determined by density, optical, and chemical tests. Other small cavities show minute crystals of quartz and velvety aggregates of goethite needles. The matrix contains small patches and veins of glassy quartz and of red earthy haematite (or hydrohaematite), while in one part of the specimen there are minute specks of fresh unaltered pyrite. A thin section of the compact dark-brown matrix examined under the microscope showed small interlocking grains of quartz and willemite. Both of these minerals are optically uniaxial and positive, but they differ widely in their birefringence (quartz 0·009, willemite 0·029). The crystals of both contain abundant yellow inclusions of limonite. Hemimorphite and smithsonite were not detected.

Other specimens more homogeneous and compact in appearance were lighter in colour, being ochre-yellow. Chemical tests showed the presence of silica, ferric oxide, zinc oxide, and water in this material. The specific gravity of small chips taken from one of these specimens ranged from 3·16 to 3·18.

This peculiar 'yellow rock' or 'yellow waste' is of considerable abundance (over 100,000 tons) at Broken Hill. It has been described by Mr. S. J. Speak[2] with special reference to its possible mode of origin. He states that it always occurs between the sulphide-ore and the dolomite walls of the ore-body, and that it frequently encloses brecciated blocks of dolomite.

Specimens of the 'yellow rock' sent to the British Museum in 1923

zinc minerals were recognized by their optical characters in the central cavity of limb bones. Appended is the following note (p. c 14):

'Enfin, je signale de jolis cristaux légèrement brunâtres, de willénite [*sic*] accompagnant de la descloizite : ces cristaux ont la forme habituelle du prisme hexagonal surmonté d'un rhomboèdre très obtus. La willémite n'a pas encore été signalée à Broken-Hill.'

[1] L. J. Spencer, On hopeite and other zinc phosphates and associated minerals from the Broken Hill mines, North-Western Rhodesia. Min. Mag., 1908, vol. 15, pp. 1–38.

[2] S. J. Speak, An occurrence of zinc silicate ore of supposed primary origin. Bull. Inst. Mining Metall. London, February 1926, no. 257, 5 pp., 2 pls.; Transactions, 1926, vol. 35 (for 1925–6), pp. 226–247, 2 pls.

by Mr. G. Chad Norris of the assay office at Broken Hill, were accompanied with the following analytical results (nos. 1–4). The analyses under nos. 5 and 6 are quoted from Mr. Speak's paper.

	SiO_2.	Fe_2O_3.	Al_2O_3.	ZnO.	PbO.	H_2O (loss on ign.).	Total.
1.	61·26	8·80	—	15·84	—	?	(85.90)
2.	27·26	60·42	—	0·49	—	?	(88·17)
3.	62·30	22·87	—	4·16	—	?	(89·33)
4.	1·60	39·91	—	33·14	—	?	(74·65)
5.	54·6	9·16	0·94	30·88	0·61	2·98	99·17
6.	44·8	23·3	0·10	19·3	4·6	3·6	99·75*

* Including in no. 6 also V_2O_5 0·42, P_2O_5 1·61, MgO 0·23, MnO 0·95, CaO 0·46, S 0·38.

These analyses show very wide variations, but (with the exception of no. 4) they can be explained as mixtures of willemite, quartz, and limonite. Mr. Norris's no. 4 is described as 'weathered', and Mr. Speak mentions that down to depths of over 50 feet the 'yellow rock' weathers to a hard clay. This specimen is duller and softer than the others, and when tested chemically was found to contain much carbonate, presumably as smithsonite. A thin section of no. 1 shows many small prisms and grains of willemite set in a matrix of minutely crystallized quartz, the whole being heavily charged with limonite inclusions.

Mr. Speak very kindly invited me to inspect the large series of specimens of 'yellow rock' and associated dolomite which he brought from Broken Hill in 1923. Those of the 'yellow rock' are all very compact and hard, ochre-yellow to brown in colour, and dull to vitreous or resinous in lustre on the fractured surfaces. To judge from their appearance alone they might very well be described as jasper or 'Eisenkiesel'. From a purely mineralogical point of view they were rather uninteresting. I was not able in a ton of material to find even a small crystal-lined cavity nor a single well-individualized mineral. Mr. Speak in his paper, says 'Microscopical examination reveals hemimorphite but no willemite'. This is clearly an error. Willemite is without doubt extremely abundant at Broken Hill, but so obscure mineralogically that it has hitherto been overlooked.

Two small specimens of well-crystallized willemite from Broken Hill came into the British Museum collection in 1920 and 1923, the first by exchange from the Museum of Practical Geology in London, and the second by donation from Mr. G. Chad Norris of Broken Hill. The crystals are prismatic with flat rhombohedral terminations, the forms being $a(10\bar{1}0)$ and $e(01\bar{1}2)$. Although small (2 mm. long) they are distinctly developed, and are colourless and transparent, though those on

the first specimen are in part iron-stained and pearly on the surface. On the first specimen the crystals form a crust on a cellular matrix of altered blende, while on the second they rest on the surface of massive radiated willemite coloured red with iron oxide. Of later growth on the second specimen are some excellent crystals of smithsonite, with the form of the rhombohedron $f(02\bar{2}1) = (1\bar{1}1)$ measuring 8 mm. along the edges.[1]

Willemite from near the Sable Antelope mine, Mumbwa, Northern Rhodesia.

This material was collected in 1919 by Mr. R. Murray-Hughes from a small deposit of manganese and iron ore one mile north of the Sable Antelope mine (38 miles NNW. of Mumbwa) in the Kafue district. The earthy manganese and iron oxides formed a circular patch about 50 feet across in brown crystalline dolomite; and in this ore were two well-defined streaks of willemite, which gave out after 50 or 60 lb. had been collected, and no further trace of the mineral could be found. Granite outcrops at about 6 miles SW. of the Sable Antelope mine, and the sedimentary rocks into which it is intruded are correlated with the Transvaal System of the Union of South Africa and the Lomagundi System of Southern Rhodesia. These specimens of willemite consist of a friable aggregate of colourless prisms up to 2 cm. long and $\frac{1}{2}$ cm. thick. The prism faces $a(10\bar{1}0)$ are striated vertically. Most of the crystals are broken at the ends, but occasionally they show rough rounded terminations of the obtuse rhombohedron $e(01\bar{1}2)$. Associated is a powdery manganiferous haematite.

Willemite from near Lusaka, Northern Rhodesia.

Specimens presented by Mr. R. Murray-Hughes to the British Museum collection in 1927 were collected by him about 10 miles NW. of Lusaka (on the railway line 65 miles south of Broken Hill) in the Loangwa (Lungwa) district. The mineral occurs in crystalline dolomite, near a contact with granite, and blocks of willemite 'as large as a cottage' are lying about on the surface. The willemite forms compact masses of radial aggregates, with fibres 1–$1\frac{1}{2}$ cm. long from each centre. The colour is white to grey or yellowish, and the material has much the appearance of wavellite. In cavities small prismatic crystals are

[1] Similar to the crystals from Broken Hill, Rhodesia, on which E. D. Mountain has recently given accurately determined constants for smithsonite (Min. Mag., 1926, vol. 21, p. 51).

developed. Associated is earthy and fibrous haematite. Native silver[1] is found with the willemite at this locality, otherwise the mode of occurrence is very similar to that near the Sable Antelope mine (100 miles to the north-west); and it is probable that the mineral will be found at other places along the granite-dolomite contact between these two points. Mr. Murray-Hughes informs me that at both places the willemite occurs in necks or plugs of brecciated dolomite, and that copper-sulphide ores are found in similar necks (100 feet to 800 yards in diameter) nearer the granite, whilst at the actual contact and in xenoliths in the granite the dolomite has been completely replaced by haematite. The native silver occurs as an irregular intergrowth in the willemite, and nuggets weighing several ounces are found in the sub-soil near the deposit.

Willemite from Guchab, Otavi, South-West Africa.

This specimen, acquired by purchase in 1924 from Mr. W. Maucher of Munich, shows stout hexagonal prisms $\frac{1}{4}$ to $\frac{1}{2}$ cm. across with botryoidal malachite on massive chalcosine. The crystals are sulphur yellow on the exterior, and somewhat resemble the crystals of mimetite from this locality; but in the interior the material is white and grey in patches. The forms are $a\,(10\bar{1}0)$ and $e\,(01\bar{1}2)$. The occurrence here is similar to those in Rhodesia; the dolomites of the Nama system being intruded by granite.

Fluorescence of willemite and of some other zinc minerals in ultra-violet rays.

During a visit in 1924 to the famous mineral locality of Franklin Furnace, New Jersey, I was privileged to see over the works and laboratories of the New Jersey Zinc Company. Amongst the many points of interest that attracted my attention was a simple arrangement for the quick detection of willemite, which is an abundant mineral in the ores of the Franklin mine, but very variable in its aspect and superficial characters. In several of the laboratories and offices there was fixed to the wall in a dark corner a small apparatus giving a high-tension spark which could be switched on from the lighting circuit. A piece of ore held beneath the spark showed up any willemite present by a vivid green fluorescence. I have repeated this experiment by exposing specimens of willemite that I collected at Franklin Furnace to the sparks of a

[1] A similar occurrence of native silver with dioptase (and willemite) in limestone is known from Mindouli, French Congo (A. Lacroix, Min. de France, 1910, vol. 4, p. 841).

Ruhmkorff coil. The idea was to apply this test to the problematical 'yellow rock' from Broken Hill in Rhodesia. A far more effective source of ultra-violet rays is, however, given by a screened mercury-vapour lamp. A very convenient form is the 'analytic quartz lamp', made by the British Hanovia Quartz Lamp Co., Ltd., which was kindly placed at my disposal by Mr. W. D. McGillivray, the London manager of the company.

A specimen of willemite (a pale-green cleavage slab) from Franklin Furnace, placed in the dark chamber of this apparatus, glowed up with wonderful brilliancy, the colour being comparable with uranium-green, and it continued to glow when taken out of the apparatus. Another specimen from Franklin Furnace, with grains of pale-green willemite embedded in a cleavage-mass of white calcite, showed a very pretty effect—the calcite fluoresced with a dark flesh-red colour in which were spots of brilliant green due to the willemite. A specimen of willemite (crusts of small yellow-brown crystals) from Altenberg in Belgium, was tried, but it showed no trace of fluorescence. Other specimens of willemite which showed no indication of fluorescence, were the small colourless crystals from Broken Hill in Rhodesia, the aggregates of colourless crystals from near Sable Antelope mine in Rhodesia, yellow crystals from Guchab in South-West Africa, and colourless crystals from Peñoles, Durango, Mexico. The massive radiating willemite from near Lusaka in Rhodesia showed a dull dark-green fluorescence, and much the same colour was shown by the dark-coloured 'troostite' variety of willemite from Stirling Hill, New Jersey. The minute reddish crystals of willemite, found in 1908 in a cavity in the Rhodesian 'yellow rock', gave a bright yellow fluorescence, and scattered over the surface of the matrix were specks of yellow, white, and bluish-purple, and some very thin veins of bluish-purple. Four other specimens of the 'yellow rock' also showed minute specks of yellow, white, and bluish-purple. The red radiating willemite, forming the base of the colourless crystals from Broken Hill, also showed a bright yellow fluorescence, though only in patches.

Some other zinc minerals from Broken Hill, Rhodesia, were tested in ultra-violet rays for comparison. Smithsonite ($ZnCO_3$) showed differences in its behaviour: (1) white mamillated coarsely crystalline material showed a bright white fluorescence with a faint greenish tinge; (2) white botryoidal finely crystalline material gave no effect; (3) the rhombohedral (f) crystals, no effect. Hydrozincite (white mamillated; evidently pseudomorphous after smithsonite) showed a bright white fluorescence.

Hemimorphite (a pale-green crystalline crust) gave a dull white. Hopeite showed a pale straw-yellow with patchy distribution on the crystals. Parahopeite also showed a pale straw-yellow. Tarbuttite and descloizite gave no result.

The most striking fluorescent effect of all was that given by a massive granular black blende from Tsumeb, South-West Africa. This was tried because it shows a very pronounced triboluminescence: when lightly scratched with a knife-blade it gives streaks of yellow sparks. In ultra-violet rays it glows with a brilliant fiery yellow like a live coal. A crystal of zincite from New Jersey showed no effect.

A set of 23 small diamond crystals from the Mazaruni river district in British Guiana, selected to show the variation in colour, crystalline form, and inclusions, was also tested in ultra-violet rays. A yellow-green octahedron showed a brilliant fluorescence of the same colour, three colourless crystals showed up a good blue, and the rest gave no effect. Dr. G. F. Kunz in 1895 attributed the fluorescence and phosphorescence that is shown by some diamonds to the presence of a hypothetical hydrocarbon, for which he gave the name 'tiffanyite'.

It is evident from these few tests that fluorescence in ultra-violet rays is not a constant and essential character of a mineral-species, being shown by some specimens and not by others. It evidently depends on the presence of some admixed impurity in the material.

The action of ultra-violet rays on a large series of minerals of all kinds was tested by G. F. Kunz and C. Baskerville [1] in 1903, and by E. Engelhardt [2] in 1912. T. Liebisch [3] in 1912 determined spectroscopically the nature of the green fluorescence from willemite. W. S. Andrews [4] has pointed out that artificially prepared willemite is only active when it contains some manganese, the shade of the green fluorescence depending on the amount of manganese present.

[1] G. F. Kunz and C. Baskerville, The action of radium, Roentgen rays and ultra-violet light on minerals and gems. Science, New York, 1903, n. ser., vol. 18, pp. 769–783. (Willemite on p. 774.)

[2] Ernst Engelhardt, Lumineszenzerscheinungen der Mineralien im ultravioletten Licht. Inaugural-Dissertation, Univ. Jena, 1912, 42 pp.; Abstract in Neues Jahrb. Min., 1913, vol. ii, p. 358.

[3] T. Liebisch, Über die Fluoreszenz der Sodalith- and Willemitgruppe im ultravioletten Licht. Sitzungsber. Preuss. Akad. Wiss. Berlin, 1912, pp. 229–240.

[4] W. S. Andrews, Notes on the preparation of some fluorescent and phosphorescent compounds. Amer. Min., 1922, vol. 7, pp. 19–23. [Min. Abstr., vol. 2, p. 22.]

PUBLICATIONS

OF THE

MINERALOGICAL SOCIETY

The Publisher is Mr. Humphrey Milford, Oxford University Press, *Amen House, Warwick Square, London, E.C.* 4.

Mineralogical Magazine.—Current Numbers price 6*s.* net each. Annual Subscription for four Numbers post free 20*s.*, payable in advance to the Publisher, either direct or through any bookseller.

Back Numbers.—With the exception of Nos. 17, 18, 19, 21, and 22, which are out of print (and some few numbers of which the stock is low and which are reserved for the sets mentioned below), all numbers can be supplied separately at the following net rates: Nos. 1–48 at 4*s.* each; Nos. 49–111 at 5*s.* each; Nos. 112 (1926) onwards at 6*s.* each. Since 1920 (Vol. XIX) the Numbers have been issued quarterly, and include a separately-paged appendix of *Mineralogical Abstracts.*

Geological Map of the Shetland Islands (separate from Vol. II). Price, 4*s.* mounted, 2*s.* 6*d.* unmounted, net.

General Index to Vols. I–X, 4*s.*; to Vols. XI–XX, 6*s.* net.

Mineralogical Abstracts (Vol. I, Nos. 1–12, 1920–22, issued with Vol. XIX of the Magazine) are also sold separately. Price 2*s.* 6*d.* net each number. Later numbers (Vol. II, 1923–25; Vol. III, 1926–) are issued only as part of the Magazine.

Bye-Laws and List of Members. Price 1*s.* net.

Part sets at the following reduced rates. Set A.—Vols. I–X (Nos. 1–48, 1876–94, and Index No.) at 4*s.* per number less 15% (to Members of the Society less 35%). Set B.—Vols. XI–XX (Nos. 49–111, 1895–1925, and Index No.) at 5*s.* per number less 15% (to Members less 35%). Set C.—Vols. I–XX (Nos. 1–111 and two Index Nos.) at the above initial prices less 20% (to Members less 40%).

Proceedings of the Crystallological Society [amalgamated with the Mineralogical Society in 1883]. Parts I and II (1877, 1882), price 4*s.* net each.

GENERAL NOTICES

Members desiring to propose Candidates for Election are requested to send the names and qualifications of the Candidates to the General Secretary, W. Campbell Smith, M.C., M.A., F.G.S., *Natural History Museum, South Kensington, London, S.W.* 7. There is an entrance fee of one guinea and the annual subscription is one guinea; the latter can be compounded for by a single payment of fifteen guineas. New Members, on the payment of their first subscription, receive all the numbers of the Magazine for the year for which the subscription is paid.

There are four meetings of the Society each year, on Tuesdays at 5.30 p.m. in January, March, June, and November. They are held (by kind permission) in the Apartments of the Geological Society, Burlington House, Piccadilly, London, W. 1. Titles of papers to be read at these meetings, with a view to subsequent publication in the Magazine, should be sent to the General Secretary at least two weeks before the meeting. Authors alone are responsible for the views set forth in their respective papers. They are allowed, free of charge, fifty separate copies of their papers published in the Magazine.

MINERALOGICAL MAGAZINE

CONTENTS OF NO. 119

(December, 1927)

PAGE

L. J. SPENCER: Specific gravities of minerals: an index of some recent determinations 337

J. DRUGMAN: On β-quartz twins from some Cornish localities. (With plates VIII and IX) 366

A. RUSSELL: Notice of an occurrence of niccolite and ullmannite at the Settlingstones mine, Fourstones, Northumberland; and of serpierite at Ross Island mine, Killarney, Co. Kerry, Ireland 383

L. J. SPENCER: South African occurrences of willemite. Fluorescence of willemite and some other zinc minerals in ultra-violet rays 388

MINERALOGICAL ABSTRACTS

(Vol. 3, No. 8, Pages 365–412)

New Minerals (p. 365).—Chemical Constitution of Silicates (p. 372).—Rock-forming Minerals and Petrology (p. 378).—Meteorites (p. 387).—Economic Minerals and Ore-deposits (p. 395).—Microscopical Examination of Opaque Minerals (p. 400).—Miscellaneous (p. 404).

PAGE

ADAM, H. R. . . 369
ADKINS, W. S. . 380
AHLFELD, F. 370, 410
ALEXANDROW, S. P. 399
ALLEN, V. T. . . 370
ALVAREZ, A. . . 387
ANTUTZ, A. . . 368
ARSANDAUX, H. . 408
AUBEL, R. VAN . 408
AUROUSSEAU, M. 385
BAUER, L. H. . 365–6
BECKE, F. . . . 382
BERNAUER, F. . 400
BINDRICH, J. . . 378
BOLDYREV, A. K. 405–6
BOWEN, N. L. 378, 387
BRAGG, W. L. . 378
BROWN, W. H. . 403
BUERGER, M. J. . 383
BURRI, C. R. . . 387
CAMPBELL, I. . . 409
CESÀRO, G. . 368, 376
CHIRVINSKY, P. N. 389, 390
COLE, L. H. . . 396
CORBETT, C. S. 382, 392
CRAWFORD, A. L. 379
CRAWFORD, W. P. 367
CREVELING, J. G. 385
DALY, R. A. . . 385
DAVISON, E. H. . 383
DITTLER, E. 377, 394
DRUGMAN, J. . . 380
DUCLOUX, E. H. . 388
DUPARC, L. . 368, 380

PAGE

ECKERMANN, H. . 384
ELLSWORTH, H. V. 366–7, 411–2
FELLENBERG, T. . 395
FENNER, C. N. . 379
FENOGLIO, M. . . 407
FLÖRKE, W. . . 402
FOYE, W. G. . . 382
FREBOLD, G. . . 402
GEIJER, P. . . . 401
GILLSON, J. L. 378, 384
GOLDSCHMIDT, V. M. 376
GORANSON, R. W. 379
GORDON, S. G. 370, 374, 412
GOSSNER, B. . . 377
GREIG, J. W. . . 412
GROUT, F. F. . . 384
GUIMARÃES, D. . 389
GYSIN, M. . . 368, 380
HALL, A. L. . . 396
HALLIMOND, A. F. 374
HENDERSON, E. P. 403, 410
HERITSCH, F. . . 382
HESEMANN, J. . 400
HESS, F. L. . . 410
HIBSCH, J. E. . . 382
HOBSON, G. V. . 390
HYNIE, O. . . . 395
JAKOB, J. . . . 376
JANISCH, E. P. . 397
JIRKOVSKÝ, R. 365, 404
JUNG, A. O. . . 394
KAUFMAN, L. E. . 406

PAGE

KERR, P. F. . . 378
KOECHLIN, R. . . 410
KOLDERUP, N. H. 381
KRYZHANOVSKY, V. I. 406
LACROIX, A. 392–3, 408
LAPPARENT, A. DE 369
LIGHTFOOT, B. . 386
LODOCHNIKOV, V. N. 406
LONSDALE, J. T. 380, 391
LUCAS, F. A. . . 395
LUGARO, G. . . 407
LUNDE, G. . . . 399
MACGREGOR, A. M. 398
MERRILL, G. P. . 391
MERWIN, H. E. . 374
MICHEL, H. . . 394
MORAES, L. J. DE 389
MYERS, W. M. . 403
NEVIANI, A. . . 393
NIEUWENKAMP, W. 393
OLSACHER, J. . . 402
ONORATO, E. . 407–8
ORCEL, J. 372, 400, 409
PALACHE, C. 365–6, 391
PÁLFY, M. . . . 396
PARKER, R. L. . 409
PASTORE, F. . . 389
PATTE, E. . . . 409
PRIOR, G. T. . . 395
QUERCIGH, E. . . 407
RAAZ, F. . . . 377
RICHARZ, S. . . 375
RIDLEY, G. N. . . 376

PAGE

ROHLEDER, H. P. T. 386
ROSICKÝ, V. . . 395
ROSS, C. S. . . . 382
SAMPSON, E. . . 403
SAUCE, W. DE LA 399
SCHAUBERGER, G. 381
SCHOEP, A. . 370–2
SCHORNSTEIN, W. 399
SCHWARTZ, G. M. 403
SCHWARZ, M. . . 394
SCRIVENOR, J. B. 367
SHANNON, E. V. . 365
SHENTON, J. C. . 367
SHORT, M. N. . . 403
SOLODOVNIKOVA, L. L. 404
STANSFIELD, J. . 385
STARK, M. . . . 381
THOMSON, E. . 400–1
THURMOND, F. L. 395
TSCHIRWINSKY, P. 389, 390
ULRICH, F. . . . 365
UNGEMACH, H. . 398
VOGT, J. H. L. 379, 400
VRABÉLY, V . . 369
WAGNER, P. A. 397–8
WALKER, J. F. . 412
WASHINGTON, H. S. 374, 383
WHEELER, E. P. . 381
WINCHELL, A. N. 373–4, 412
ZECHMEISTER, L. 369
ZERNDT, J. . . . 383

Printed in England by JOHN JOHNSON, at the University Press, Oxford

RE-PRINT LITHO by COLONNA PRESS LIMITED, QUEENSWAY HEMEL HEMPSTEAD, HERTS.